Section 5

FISH RESOURCES

by

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5.1 SUMMARY

The North Aleutian Shelf nearshore zone (O-50 m) is a gradually sloping shoreward extension of the relatively shallow Bering Sea middle shelf. The fish community of the nearshore zone is likewise an extension of that occurring on the middle shelf, consisting largely of similar pelagic species (salmon, sand lance, young-of-year cod) and demersal species (yellowfin and rock sole, pollock, Pacific cod), except in nearshore habitats such as lagoons and embayments where the fauna is more diverse (sand lance, herring, capelin, salmon, yellowfin sole, smelt, sculpin, greenling, and other species). Some fish inhabit the nearshore zone year-round while others are present seasonally; highest usage occurs during spring and summer months (Fig. 5.1). The fish fauna can be separated into three ecologically distinct groups--forage fishes, salmon, and demersal fishes.

Forage fishes migrated into shallow areas in large schools in spring to spawn (herring, capelin) and/or to feed (sand lance). This seasonal occurrence of these highly mobile species resulted in an abundant supply of forage fishes (peaking at over 10 g/m^2 of sea surface area) available for seabirds, marine mammals and other fishes from spring through mid-summer. Fluctuations in abundance from year to year are probably high; for example, capelin are reported to be abundant in some years but few were caught in 1984 or 1985. The main foods eaten by forage species were zooplankton (euphausiids, copepods, and crustacean larvae).

Salmon are a significant component of the nearshore environment in spring and early summer. Though salmon adults and juveniles are most abundant farther offshore, several million adult salmon, mostly sockeye and chum, migrate through nearshore waters on their way into Bristol Bay. During this time, many continue to feed (mainly on euphausiids), accumulating final food reserves for migration and spawning requirements. Juvenile salmon also feed in and pass through the study area on their migration out of Bristol Bay. Juvenile salmon ate zooplankton (euphausiids, copepods, and decapod larvae), epibenthos (mysids and amphipods), fish (primarily sand lance), and insects.

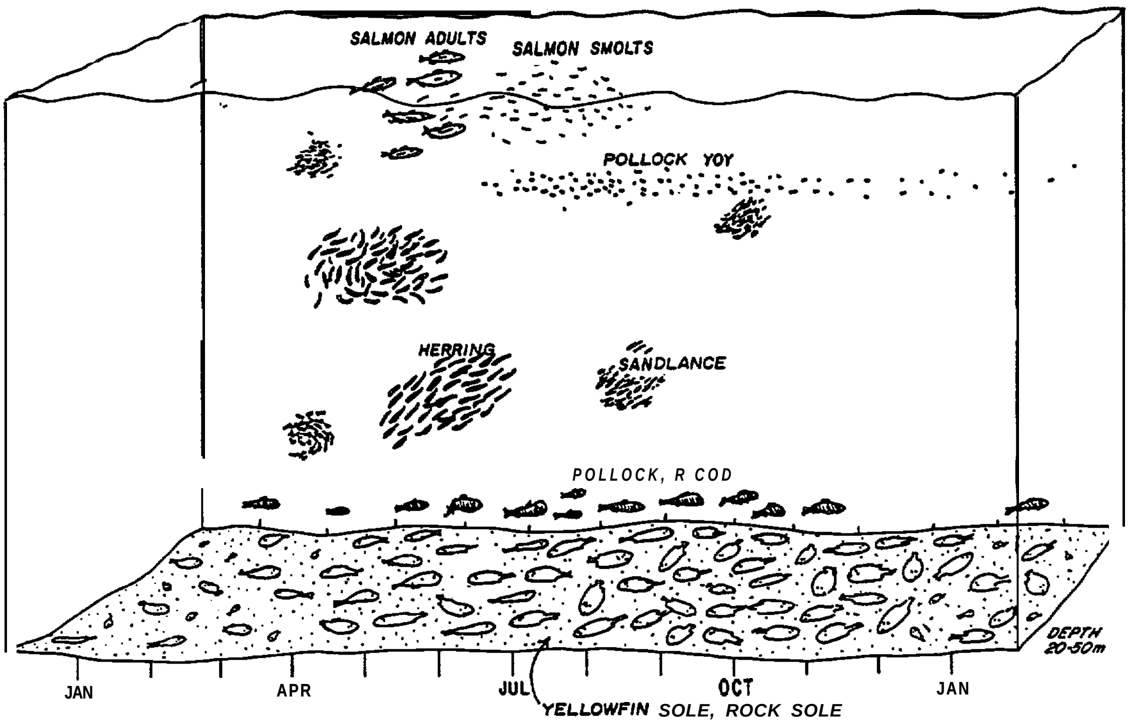


Figure 5.1. Schematic diagram showing seasonal patterns of fish use in the North Aleutian Nearshore Zone.

Demersal fishes in the nearshore zone were dominated by yellowfin and rock sole, which together comprised about 80% of the total biomass caught by bottom trawls in this study. Pollock and Pacific cod were also common, but all of these species are reported to be equally or more abundant elsewhere in the eastern Bering Sea. Use of the nearshore waters by demersal species was greatest in summer when a peak abundance of 4.5 g/m^2 was recorded, but this biomass is thought to be a gear-biased underestimate. Although many demersal fishes vacated shallow waters in winter, juvenile yellowfin and rock sole wintered there. Demersal fish abundance was annually variable as well.

Foods of the demersal fishes varied among fish species and ages. Yellowfin and rock sole consumed epibenthic and infaunal invertebrates. Small soles ate copepods, amphipods, polychaetes, and fish; large ones ate polychaetes, crangonid shrimp, bivalves, fish, and a variety of other benthic invertebrates. Young-of-year pollock and Pacific cod ate mainly zooplankton (copepods, crustacean larvae, and amphipods). Older juveniles of these species ate primarily epibenthic invertebrates and some fish. Adults ate fish, euphausiids, and various crabs.

5.2 INTRODUCTION

The productive waters of the southeastern Bering Sea are among the world's richest fishing grounds. Over 300 fish species, about 20 of which are of major commercial importance, inhabit the area. Large quantities of salmon, cod, pollock, flatfish and other species are harvested annually. Though most of the commercial fisheries operate outside the North Aleutian Shelf nearshore zone (O-50 m water depth) addressed in this study, many of the species involved migrate through or disperse into shallow waters during particular phases of their life cycles. Other species, not of commercial value, occur in the study 'area in vast numbers and are a vital component in the diets of other fishes, seabirds, and marine mammals.

The importance of these resources in the eastern Bering Sea has been well-documented (e.g., Rood and Calder 1981, Lewbel 1983, Pace 1986), but little is known about fish use of shallow-water habitats adjacent to the North Aleutian Shelf lease area. Specific objectives of the present study were to describe the nearshore fish community and to obtain estimates of fish abundances, seasonal and spatial distributions, and dietary requirements. The approach followed in this section will be to use new data and available literature to examine how fish use shallow coastal waters and, for perspective, to determine whether these uses are specific to, or dependent on, shallow water habitats.

5.3 SOURCES OF INFORMATION

The eastern Bering Sea has long been the focus of fisheries studies, and a vast body of information has accumulated (e.g., Thorsteinson and Thorsteinson 1982 and 1984). Detailed reviews of the commercial species are available for salmon (e.g., Straty 1974, Neave et al. 1976, French et al. 1976, Hartt 1980, Straty and Jaenioke 1980, Straty 1981, Bax 1985, Isakson et al. 1986), groundfish (e.g., Pereyra et al. 1976, Hood and Calder 1981, Smith and Bakkala 1982, Forester et al. 1983, June 1984, Bakkala et al. 1985), and herring (e.g., Warner and Shafford 1981 , Wespestad and Barton 1981, Wespestad and Fried 1983, Fried and Wespestad 1985). The fishery resources are monitored annually by the Alaska Department of Fish and Game (ADFG) and the National Marine Fisheries Service (NMFS). ADFG (1985) has distilled much of this information in their statewide series of Habitat Management Guides. Other general sources of information include a review of fishes in the Unimak Pass area (Craig 1986), an extensive compilation of information about forage fishes and other non-salmonlds in the eastern Bering Sea (Macy et al. 1978), and the distribution of lchthyoplankton (Waldron 1981).

The shallow waters of the study area have historically received much less research attention than have waters deeper than 50 m, but some data are available. Recent OCSEAP studies have examined bottomfish, juvenile salmon, and forage fishes in shallow waters along the northern coastline of the Alaska Peninsula (Barton et al. 1977, Warner and Shafford 1981, Cimberg et al. 1986, Isakson et al. 1986). 'Other sources of information include descriptions of fishes in Izembek Lagoon (Tack 1970, Smith and Paulson 1977, McConnaughey 1978), ADFG catch statistics for small commercial fisheries for salmon (Urilia Bay, Izembek Lagoon area, Port Moller area) and herring (Port Moller), catches of adult salmon in a test fishery off Port Moller (Eggers and Fried 1984), and salmon escapement counts for some streams on the Alaska Peninsula which flow into the study area (ADFG 1985).

5.4 STUDY AREA

This study focused mainly on the nearshore zone from O-50 m deep (herein called the North Aleutian Nearshore Zone, NANZ) along the northern coastline of the Alaska Peninsula between capes Mordvinof and Seniavin (Fig. 5.2). Aquatic habitats in the NANZ fall into two *natural.* groupings: (1) the coastal zone extending from shore out to the 50-m isobath, and (2) varied nearshore habitats such as lagoons and embayments. Brief descriptions follow. (For more details, see Section 2.0, this report).

5.4.1 Coastal Zone

The eastern Bering Sea is characterized by three hydrographic domains: coastal (O-50 m), middle (50-100 m), and outer domain (100-150 m). NANZ is usually contained within the well-mixed coastal domain, although some vertical stratification of the water may occur when thl s zone is affected locally by freshwater runoff or when there is a shoreward intrusion of the middle domain. Freshwater inputs by rain and runoff are

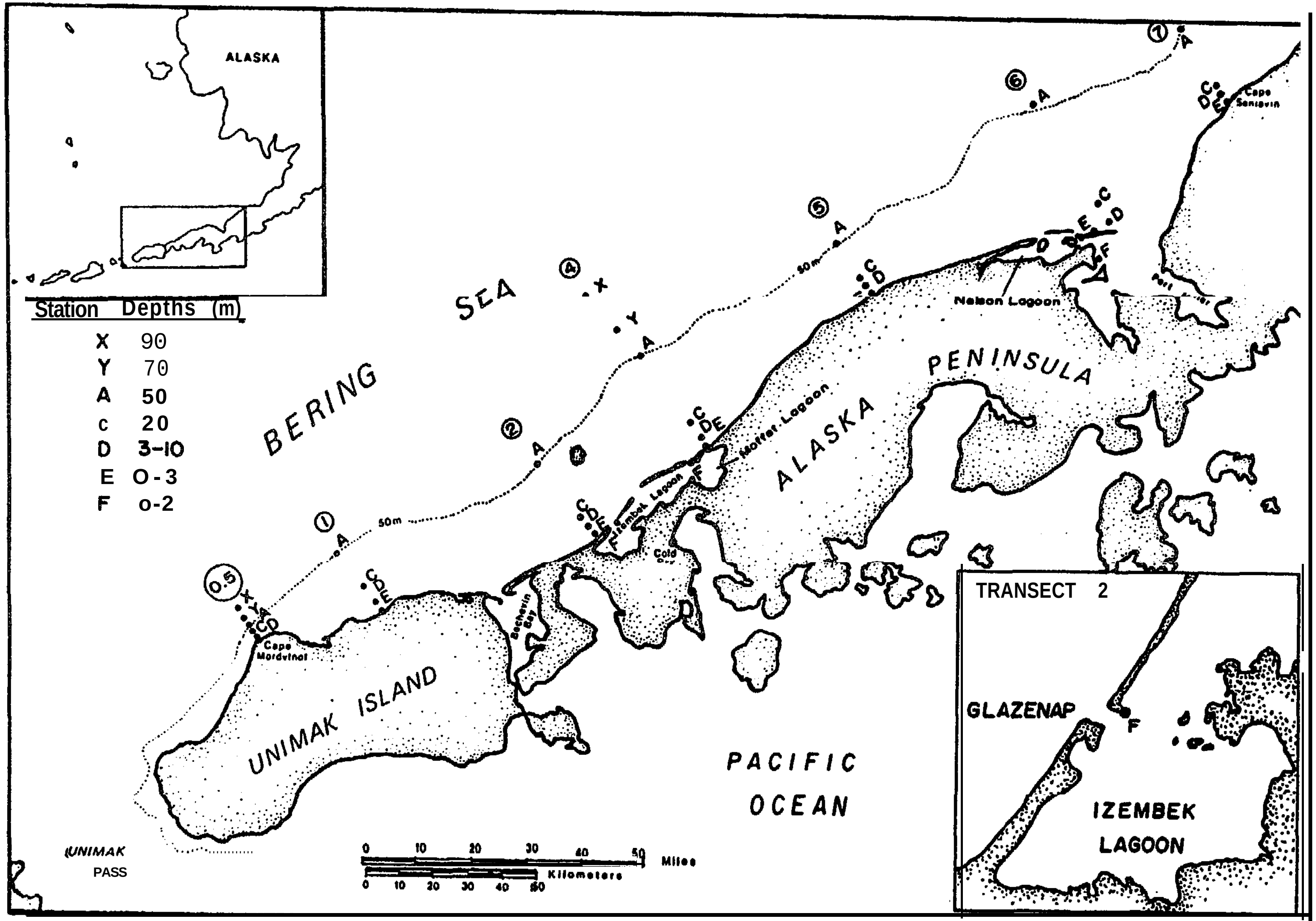


Figure 5.2. Fish sampling sites in the North Aleutian Nearshore Zone (NANZ) study area, Alaska, showing locations of Transects 0.5-7 and sampling station depths. The lower inset shows the primary sampling site (2F) in Izembek Lagoon.

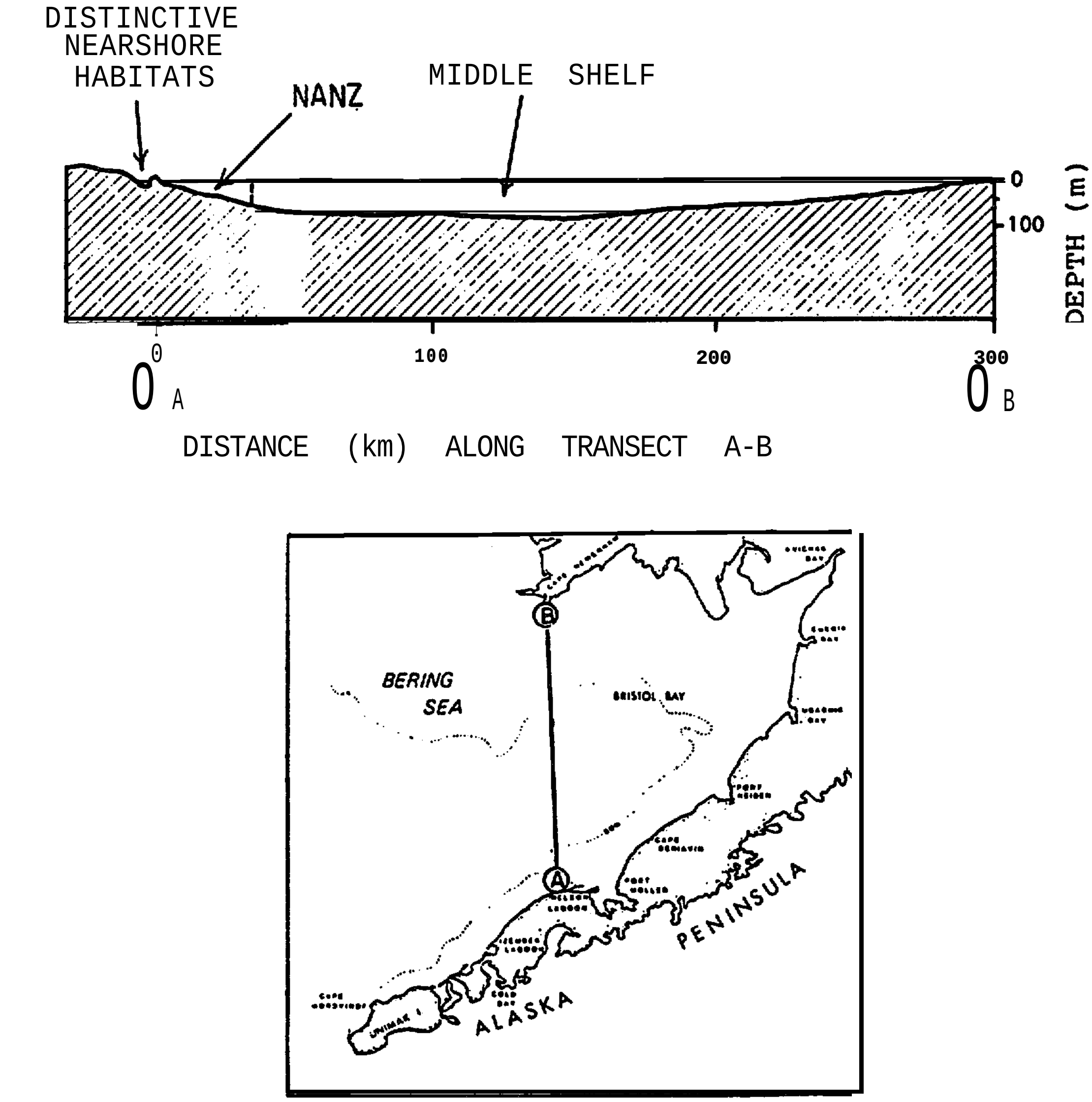


Figure 5.3. Schematic cross-section of the eastern Bering Sea showing habitats along a transect extending from the Port Moller area (A) to Cape Newenham **(B)**. (NANZ = North Aleutian Shelf Nearshore Zone.)

minor contributors to the coastal water mass in this area.

The coastal zone is a relatively homogeneous habitat, consisting of a gentle slope of sand, gravel and shell hash substrates, interrupted by a single island, Amak Island (Fig. **5.2)**. The continental shelf in this area continues to slope gently beyond the 50-m isobath, leveling off at about **80-100** m (Fig. **5.3)**.

During the course of this study, the salinity of the **NANZ** remained nearly constant at about **31.5** ppt (Fig. **5.4)**. Shoreline waters (at the 1-

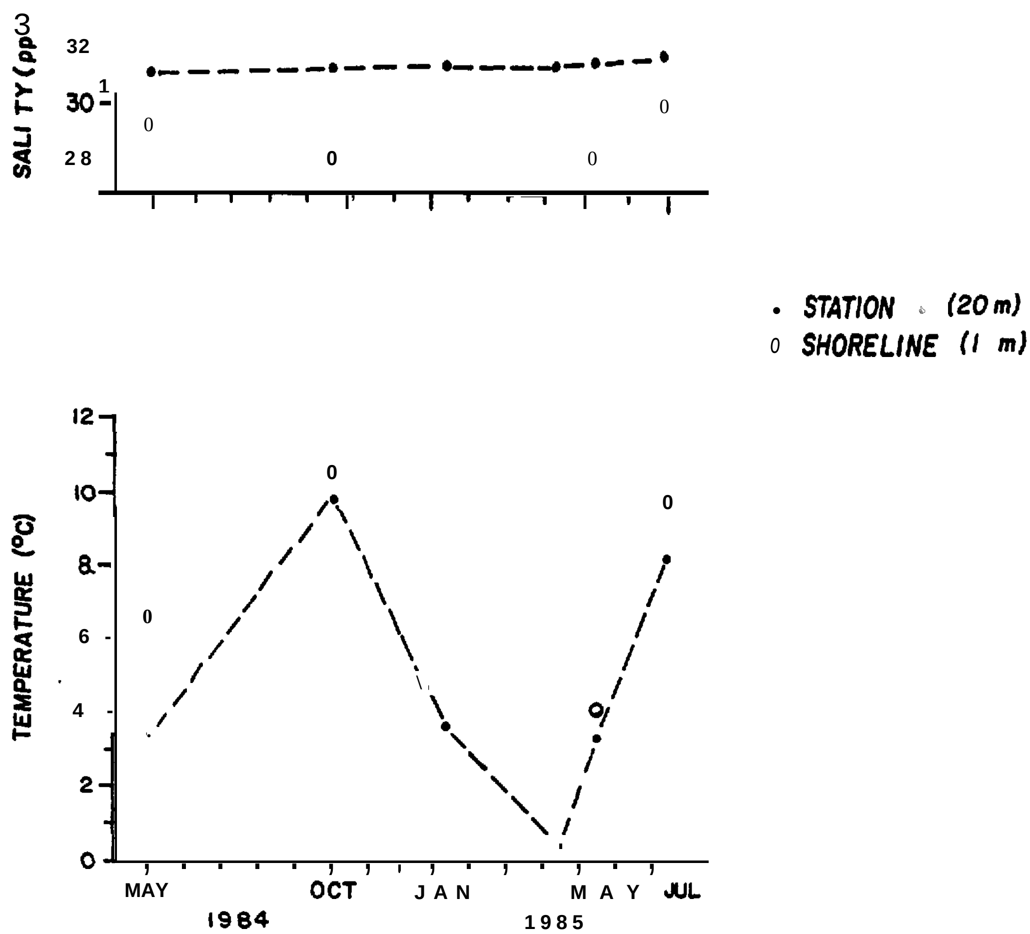


Figure 5.4. Seasonal water temperature and salinity trends at Stations C (20 m) and E (1 m) in the NANZ study area, Alaska. Shoreline values are means of measurements taken in 1 m of water (n = 3-8 transects). For Station C (20 m), temperatures and salinities are average values at mid-depth (10 m).

m isobath) tended to be about 2-3 ppt less saline than offshore waters (at the 20-m isobath) due to freshwater runoff from the Alaska Peninsula.

Water temperatures in the NANZ varied from summer highs of about 9-10 C to winter/spring lows of 0.5-3.5 C (Fig. 5.4). Shoreline waters tended to be 1-3 C warmer than offshore waters.

In extremely cold winters, the Bering Sea icepack may extend as far south as the study area, but this did not occur during 1984 or 1985.

5.4.2 Nearshore Habitats

Nearshore habitats are defined as those waters that *are very* shallow, immediately adjacent to the coast, and inshore from the coastal zone. Exposed shorelines and embayments are included in this category.

5.4.2.1 Exposed Shorelines

The north side of the Alaska Peninsula presents a relatively straight coastline with direct exposure to the Bering Sea. There are some rocky headlands, but most oftheexposed shoreline consists of black sand and gravel beaches, pounded by a rough surf. Beaches are littered at the high tide mark by fisherman's lines, buoys and other debris cast up by frequent and forceful storms in the Bering Sea. Kelp beds are generally absent except at Amak Island and a few other scattered areas. About 98 streams, most very small (2-5 km long) but still supporting salmon populations, flow into the study area between Capes Mordvinof and Seniavin.

5.4.2.2 Protected Embayments

Three major embayments are located along the NANZ coast: Izembek Lagoon/Moffet Lagoon, Port Moller/Nelson Lagoon, and Bechevin Bay. Izembek Lagoon is large (218 km2) and shallow, consisting primarily of tidal mud flats (78% of surface area) which support extensive eelgrass beds. Several small salmon streams flow into the lagoon, and a small amount of commercial fishing for adult salmon occurs in the deeper portions of the lagoon in summer. Port Moller is a very large and complex water body containing a diverse array of aquatic habitats, from expansive tidal mudflats in *Nelson* Lagoon to inner embayments up to 40 m deep. Small fisheries for both salmon and herring occur in the Port Moller area. Bechevin Bay was not examined.

5.5 METHODS

5.5.1 Collection Activities

The fish community of the NANZ between capes Mordvinof and Seniavin was sampled at seasonal intervals in 1984 and 1985. Five cruises aboard the RV Miller Freeman and an additional shore-based sampling effort in Izembek Lagoon were made, as follows:

PERIOD	AREA SAMPLED
1. 10-25 May 1985	(NANZ)
2. 7-13 July 1985	(Izembek Lagoon)
3. 18 Sept.-4 Oct. 1985	(NANZ)
4. 23 Jan.-2 Feb. 1986	(NANZ)
5. 17-25 May 1986	(NANZ)
6. 19 July-l Aug. 1986	(NANZ)

The primary sampling design for the NANZ cruises consisted of seven transects extending from the shoreline out to the 50-m depth contour (Fig. 5.2). Two modifications to this design were that Transects 2, 4 and 6 extended landward into Izembek Lagoon and Port Moller, and in 1985 Transects 0.5 and 4 extended seaward to about the 90-m depth contour.

Fish sampling stations on each transect were located at the shoreline and the 3-10, 20, 35, and 50 m depth contours, together with additional sampling stations inside lagoons (Transects 2, 4, 6) and at the 70 and 90 m contours (Transects 0.5, 4). For the purposes of this report, Transects 0.5 and 1 have been combined and labeled Transect 1.

A variety of methods was used to sample different components of the fish community (Table 5.1). Total sampling efforts during Periods l-6 are listed in Table 52. Additional details about gear dimensions and methods of collection are presented in Table 5.3 and below:

Gill Nets. Two sizes of gill nets were used, a large net (200'x20') for sampling offshore sites (20-50 m water depths) and a smaller net (100'x6') for sampling nearshore sites (O-10 m depths). Both surface and bottom nets were used at most

Table 5.1. Sampling gear used at various water depths along a **shore-to-sea** transect.

Water **Depth (m)**	Station	Gear*	**Sampling** Platform
Shoreline	E	**gn,bs**	Zodiac inflatable
3-10	D	**gn,bt**	Monark Launch
20	C	**gn,bt,mt**	RV _Miller Freeman_
50	A	**gn,bt,mt**	RV _Miller Freeman_
70	**Y**	**bt,mt**	RV _Miller Freeman_
90	X	**bt,mt**	RV _Miller Freeman_

* gn (gill net), bs (beach seine), bt (bottom trawl), mt (**midwater** trawl).

Table 5.2. Sampling effort per sampling period.

Gear	Gear Code	**Sampling** Period 1	2	3	4	5	6	Total
Gill net (offshore)	GN-S,GN-B	14						14
Gill net **(nearshore)**	**GNXS,GNXB**	6	5	12				47
Beach seine	**BS-1,BS-3**	9	6	19		523	8 16	62
Trynet bottom trawl	TRY1	36		38 1	26	15	28	143
Misc. bottom trawl		17		3				18
831112 bottom trawl	BT-1						1	4
Marinovitch **midwater** trawl	**M-4**			22	16	13	22	73
Misc. **midwater** trawl	-							31
Misc. gear	-	14	8	17	9		10	34

[1] **Period 1 (10-25 May 1984, 2 (7-13** July **1984),** 3 **(18** September-4 October **1984), 4 (23** January-2 February **1985), 5 (17-25 May 1985), 6 (19 July-1** August **1985).**

Table 5.3. Description of sampling gear and gear codes.

Code Net Type	Dimensions	Mesh (Stretched)	Comments and CPUE Units
Gill Nets			
GN-S GN-B Offshore nets	200x20′	1.5,2.5,3.5,4.5"	Monofilament, both floating (GN-S) and bottom (GN-B) nets. No./h
GNXS GNXB Nearshore nets	100x6′	1,2,3,4"	Monofilament, both floating (GNXS) and bottom (GNXB) nets. No./h
Bottom Trawls			
TRY1 Trynet (otter) trawl	12′ opening, 16′ long	1.5" with 0.75" codend liner	No./m^2
ST-1 83/112 trawl	83' headrope, 112' foot-rope, 53' horizontal and 7' verticle opening when trawling	4" with 3.5" codend and 1.25″ liner	No./m^2
Midwater Trawls			
H-3 trynet	16' opening, 24' long with attached depth sounder	1.5" with 0.75" codend liner	Used May 1985 cruise only. No./m^3
M-4 Marinovitch	50' long, 33 ' diameter	graduated (3,2.5,2,1.25") with 0.5" liner	80 m^3 mouth area. No./m^3
M-6 Diamond	12x12 fm mouth	graduated (4-36")	No./m^3
Zooplankton Trawl			
Bongo nets	60 cm diameter	505 micron	No./m^3
Seines			
BS-1 Beach seine	200x6 '	0.75"	Nylon maqulsette. No./haul
BS-3 Beach seine	100x6′	1″	Nylon maqulsette. No./haul
Sonar Transects	38 khz		Slmrad
Misc. Miscellaneous			
Rook dredge	1.5x4' mouth	1 mm	
Drift net	1x2′ mouth		
Pyke net	4x4′ mouth		Izembek Lagoon only
Hook & line			Creel census
Epibenthic sled	1x3′ mouth		

stations. The small gill net was set along shorelines in protected waters (lagoons), or seaward of the surf zone along exposed coastlines (about 100 m offshore). Use of the large nets was discontinued after Period 1 due to difficulties in retrieving the nets with available small boats.

Gill net sets averaged 9 hr (range 2-23 hr). Total sampling efforts with the various types of gill nets (see Table 5.3 for gear codes) were: GN-S (7 sets, 48 h), GN-B (7 sets, 45 h), GNXS (31 sets, 306 h), GNXB (16 sets, 451 h).

Bottom Trawls. Demersal fishes were sampled using a Trynet (otter) trawl which was towed by the *Miller Freeman* at deep stations (20-50 m) and by the ship's launch at shallow stations (3-10 m). Trawls were towed for approximately 10 min at 2.5 kt. The distance towed was determined by Loran coordinates except during Period 1 when the distance trawled at shallow sites was estimated based on an average boat speed of 2.3 kt for 10 min. Catch per unit effort (CPUE) and biomass per unit effort (BPUE) were calculated according to the area (m^2) sampled which was typically 1500-3500 m^2 per trawl.

On four occasions, a larger trawl (the 83/112 trawl = BT-1) was used to evaluate whether large demersal fishes were avoiding the smaller Trynet trawl.

Midwater Trawls. Midwater samples were taken by Trynet (Period 1) and Marinovitch (Periods 3-6) trawls. Tows were 10 min at 2.5 kt and the distance trawled was determined by Loran coordinates. Horizontal tows were made at depths where the shipboard echosounder (38 khz) showed the highest apparent density of fish, thus catch values were assumed to be maximal. At the same time, however, some of the smallest fish caught (sand lance, young-of-year pollock) were observed falling through the trawl mesh as the nets were hauled aboard ship. The magnitude of such losses is not known.

Midwater catches in the Marinovitoh trawl (M-4) were generally low, so a larger midwater trawl (M-6) was used on three occasions in September 1984 for comparative purposes to see if the smaller trawl might be missing large mobile fish. The results suggest that this was not the case because the larger trawl caught fewer ffsh. The CPUE and BPUE of the M-6 (0.0003 fish/m^3, 4 mg/m^3) were much lower than those obtained by the M-4 during the same period (0.017 fish/m^3, 49 mg/m^3), presumably because the larger mesh of the M-6 did not retain the smaller fish which were often the only fish present.

Zooplankton Trawls. Larval fish were sampled by bongo net (505 micron mesh) towed obliquely for 5-10 min from water surface to about 5 m above the seabottom and back to the surface. An Oceanics flow meter attached to the mouth of the bongo net was used to calculate the volume of water filtered.

Beach Seine. The beach seining effort consisted of 1-3 hauls at shoreline stations except where wave action prohibited sampling .

Creel Census. Fish caught by hook and line provided a few samples of large halibut which were not caught by other means.

Other Methods. Additional stomach samples of fishes from the study area were provided to us by Steve Fried, ADPG (adult chum and sockeye salmon) and John Isakson, Barnes and Moore (juvenile salmon).

Captured fish were identified, measured (to the nearest mm), and weighed (to the nearest g for fish over 10 g, and to the nearest 0.1 g for fish less than 10 g). Stomach contents of fish were preserved and later examined in the laboratory where contents were identified and weighed (damp weight) to the nearest 0.001 g. These weights were summed for the fish group being examined, and the composition (%) of food items in the diet of this group was calculated as the proportion of each food category in the total weight of identifiable foods in the collective stomachs. The weight of the unidentifiable portion of contents was excluded from the above calculations but inoluded in the total weight of oontents in the stomachs. One exception to these procedures occurred with adult chum salmon--in this case, virtually all of the stomach contents were unidentifiable (99.8%) and so the remaining 0.2% was not expanded in the above manner.

5.5.2 Echosounder Analsses

A Simrad EQ 38 kHz echosounder was used on all Miller Freeman cruises to help evaluate patterns of fish abundance in the study area. During trawls and continuous seabird/marine mammal surveys, the echosounder tapes were marked at 10-min intervals. At these times, the ship% course, speed and position, and the water depth were recorded.

For each 10-min segment of recording, the echograms were compared visually against standards consisting of 10 levels (0-9) graduated by echo density. A standard of 0 represented the faintest density of tracings on the echogram and a standard of 9 represented the densest concentration of tracings. For analysis, an overlay was used to cover the echogram and restrict visual reference to a single depth stratum of 1-2 m. The area of the stratum examined was approximately 1-2 m x 100 m for trawls and 1-2 m x 600 m for continuous surveys. Echosounder tapes were coded independently by two technicians whose readings were very similar (oorrelatlon coefficient = 0.97).

Two kinds of analyses were conducted. First, estimates of fish abundance in 61 midwater and 33 bottom trawls (i.e., CPUE, BPUE, mean weight of fish) were compared by correlation coefficient to the density value on the echogram at the depth where the trawl was towed. For these trawls, an average echogram density was obtained from the values at the beginning, middle, and end of the tow. Second, an overview of the study area was obtained from the echograms during the sets of continuous surveys. For these surveys, an estimate of hydroaaoustic echo density was made within each 10-m depth stratum of the watercolumn at the beginning, middle, and end of eaoh 10-min segment. Depending on water depth, between 9 and 30 depth strata rectangles were coded for each 10-min segment. These data were examined as both the average and maximum echo-intensity within the watercolumn per 10-min segment.

5.6 RESULTS AND DISCUSSION

5.6 .1 Regional Perspective

The NANZ study area is, in large part, a gradually sloping shoreward extension of the relatively shallow, featureless basin of the Bering Sea middle shelf (Fig. 5.3). The primary differences between the NANZ and middle shelf waters are depth (O-50 m vs. 50-100 m) and watercolumn structure (mixed vs. layered--see Section 2.0, this report), differences that could, in theory, affect fish populations. A major hypothesis investigated was that the abundance and species composition of the important fishes are different in the NANZ than they are in deeper, farther offshore waters. As described below, this hypothesis could not be validated--the dominant fish species in the NANZ (excluding those species found only in very shallow shoreline habitats such as lagoons) were the same as those occurring across the vast middle shelf. Thus, one might view the NANZ as the periphery of an expansive continental shelf rather than as a unique habitat for fish.

5.6 .1 .1 Demeraal Fishes

The annual trawl surveys conducted by NMFS provide a good overview of the demeraal fish community in the eastern Bering Sea, including areas adjacent to the NANZ. It is clear from these surveys that the spatial distribution patterns of demeraal fishes vary from year to year; areas of highest abundance occur adjacent to the NANZ in some years (Fig. 5.5).

Walters and McPhail (1982) applied numerical classification techniques to the NMFS trawl data to examine large-scale patterns in the community structure of demeraal fishes in the eastern Bering Sea. Two major groups of organisms (species assemblages) repeatedly emerged in their analyses--a middle shelf group and an outer shelf group (Group 2 and Group 3, respectively, in Fig. 5.6a). The outer shelf group, found between about the 70-and 260-m iaobatha, was dominated primarily by pol lock. The middle shelf group, located between the 25-and 100-m iaobatha, was dominated by yellowfin sole and pollock.

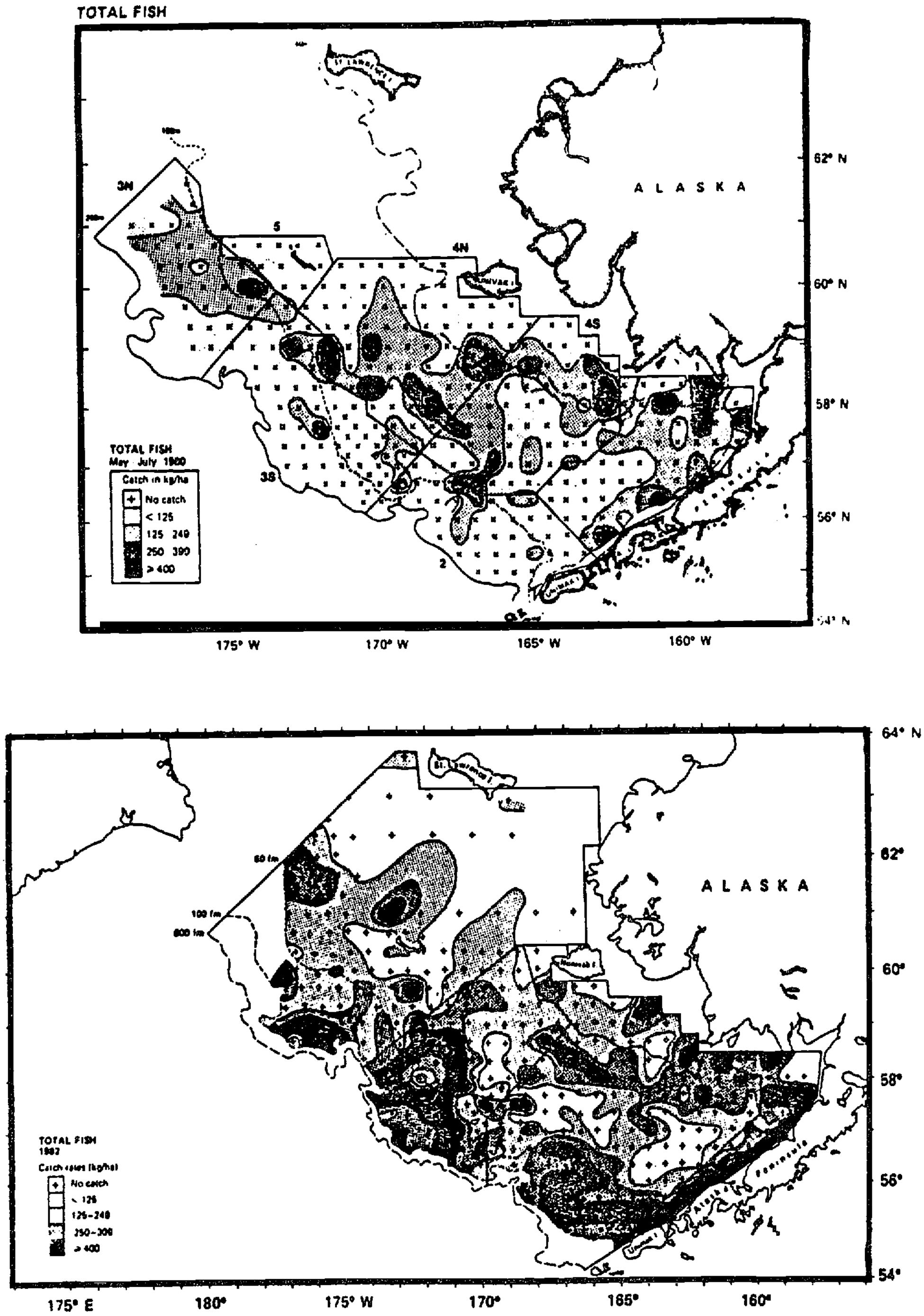


Figure 5.5 Biomass distributions of total fish catches by NMFS trawl surveys in 1980 (top) and 1982 (bottom) in the southeastern Bering Sea. From Umeda and Bakkala (1983) and Bakkala et al. (1985).

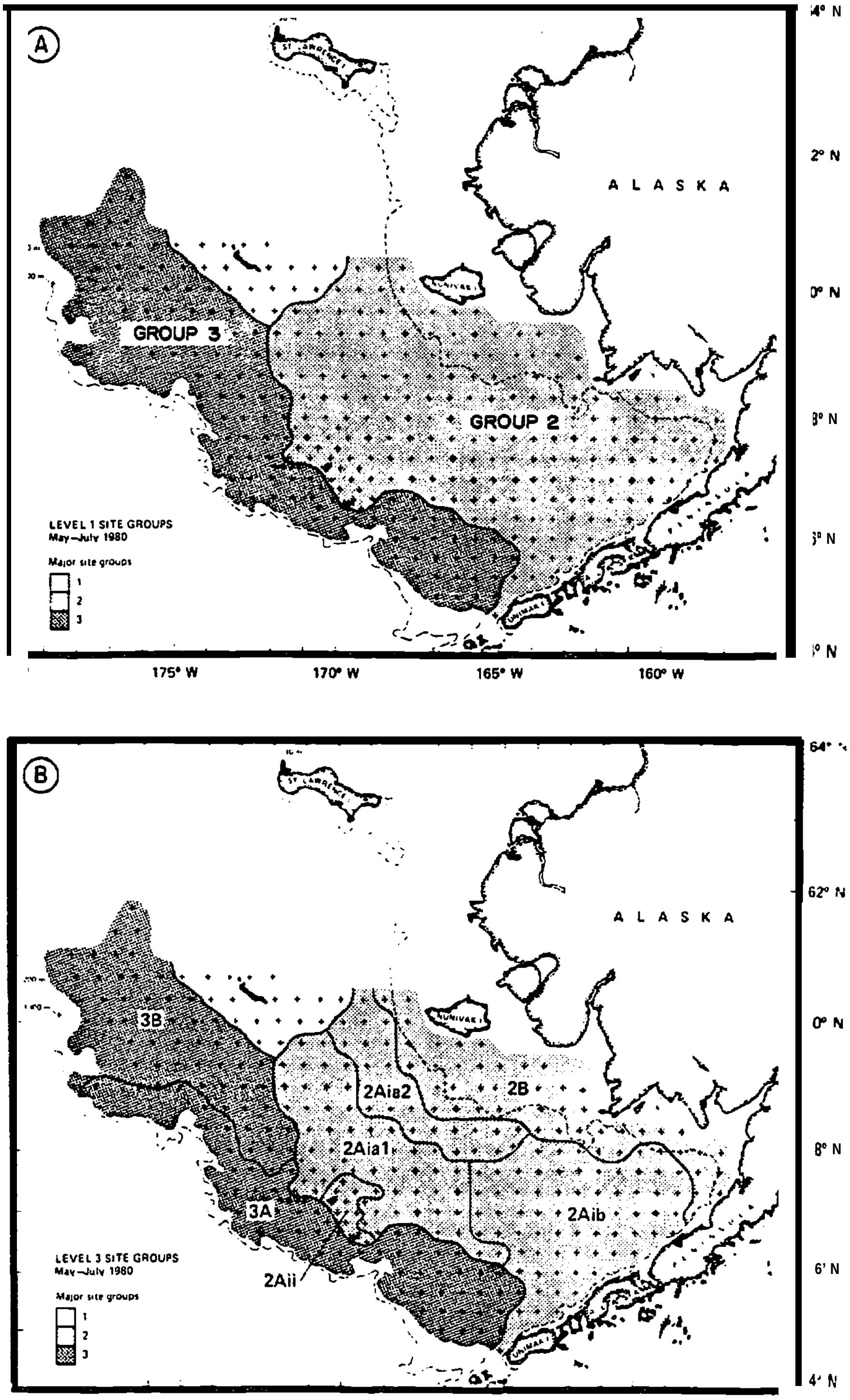


Figure 5.6. Species assemblages of fish and invertebrates in the eastern Bering Sea (1980), illustrating major groupings (top) and subgroupings (bottom). From Walters and McPhail (1982).

The middle shelf group is of particular interest because it shows that the NANZ lies adjacent to, or is part of, a fairly homogeneous and widespread community of demersal fishes. Yellowfin sole and pollock account for an average of 65% of the total fish biomass in the middle shelf region, followed by Pacific cod, Alaska plaice and rock sole (22%), and miscellaneous other fishes (Table 5.4). The community structure in the middle shelf subarea immediately adjacent to the NANZ (Subarea 2Aib in Fig. 5.6b) is similar; the dominant species in the two areas are the same but the fish tend to be more abundant in the subarea. These same species are also abundant in the NANZ, as will be described shortly.

5.6.1.2 Pelagic Fishes

Biological associations of pelagic fishes over the Bering Shelf are less well known than are those for the demersal species. Smith et al. (1984) note that the pollock is probably one of the dominant members of the midwater zone; it is widespread and abundant over the outer and middle shelf areas. About 10 other pelagic species are also important as resident or migratory members of the middle shelf community: salmon (5 species), herring, capelin, rainbow smelt, eulachon, and sand lance (Macy et al. 1978). With the exception of eulachon, these pelagic species are also abundant in the NANZ.

5.6.2 Species Composition and Relative Abundance

The shallow coastal waters of the eastern Bering Sea support a diverse fish fauna--nearly 100 species have been collected there (summarized by Isakson et al. 1986). Fifty-eight of these species were caught in the NANZ during this study (Table 5.5) though only ten species contributed 10% or more of the total numbers or biomass of catches by any one gear type (Table 5.6). The composition of the catch varied according to the sampling gear used and the habitat sampled. (Sampling gear and habitat are related, in that different gear types generally are used to sample different habitats.) Detailed results about catches by gear type are listed in Appendix 5.1.

Table **5.4.** Species composition **and** abundance of demersal **fishes** which characterize **(a) the middle Bering Shelf,** and **(b)** the middle **shelf subarea adjacent to the NANZ** (see Fig. **5.6),** based on **NMFS** trawl data Source: Walters and **McPhail 1962.**

Fish	Species	BPUE[1] Middle[2] Bering Shelf kg/ha	%	Subarea5 Nearest NANZ kg/ ha	%
Yellowfin sole	Limanda aspera	67	38	103	43
Walleye pollook	Theragra chalcogramma	47	27	62	26
Pacific cod	Gadus macrocephalus	19	11	26	11
Alaska plaice	Pleuronectes quadrituberculatus	10	6	13	5
Rock sole	Lepidopsetta bilineata	9	5	18	8
Sculpin	Myoxocephalus spp.	5	3	4	2
Greenland turbot	Reinhardtius hippoglossoides	2	1	t	t
Yellow Irish Lord	Hemilepidotus jordani	2	1	*	t
Flathead sole	Hippoglossoides elassodon	2	1	3	1
Wattled **eelpout**	Lycodes palearis	2	1	1	t
Longhead dab	Limanda Droboscidea	1	1	3	1
Sculpin	Gymnocanthus spp.	1	1	•	t
Pacific halibut	Hippoglossus stenolepis	1	1	2	1
Skates	Raja spp.	1	1	1	t
Eelpouts	Lycodes spp.	1	1	*	t
Butterfly **sculpin**	Hemilepidotus papilio	1	1	*	t
Sturgeon poacher	Agonus acipenserinus	*	t	1	t
Other		4	2	3	1
Total Fish		175		240	
Water Depth **(m)**					
Mean		69		58	
Range		1 l-274		11-102	
No. Trawls		944		319	

*<0.5.

‘Biomass per unit effort, four-year average **(1978-1981).**

[2]**Region** 2 in Walters and **McPhail** 1982 (see Fig. **5.6a).**

[3]**Areas 2A (1978),** 2Aib **(1979,1980),** and 2B **(1981)** in Walters and **McPhail** 1982. This **area** is roughly similar to **NMFS** Subarea 1.

Table 5.5. Fish species, codes and total catches in the NANZ, 1984-85.

Species	Code	Total Catch	Species	Code	Total Catch
Alaska plaice	AKPL	269	Pink salmon	PINK	10
Aleutian alligatorfish	ALAL	17	Plain sculpin	JOAK	8
Arrowhead sculpln	AHSC	1	Prickleback (unident.)	PRIC	4
Arrowtooth flounder	ARRO	51	Rainbow smelt	RBSM	1,848
Bering flounder	BERF	4	Red Irish Lord	REDL	6
Bering (warty) poacher	BPOA	189	Ribbed sculpln	RIBS	8
Butter sole	BUTS	34	Rock greenling	RGRE	7
Capelin	CAPE	5	Rock sole	ROKS	3,729
Chum salmon	CHUM	255	Sablefish	SABL	6
Crested sculpin	CRES	3	Salmon (unident.)	SALM	13
Crescent gunnel	CRGU	11	Sand sole	SSOL	1
Crescent prickleback	P-2	4	Sculpin (unident.)	SCUL	12
Dolly Varden	DOLL	16	Silverspotted sculpin	SILV	20
Eulachon	EULA	1	Slim sculpin	SLIM	1
Flatflsh (unident.)	F-l	8	Smooth lumpsucker	SMLP	1
Flathead sole	FLAT	152	Snailfish (unident.)	SNAL	128
?Flathead sole (larvae)	L-2	10	Snake prickleback	SNAK	26
Great sculpln	GRSC	22	Sockeye salmon	SOCK	12
Greenland turbot	GRTU		Spiny lumpsucker	SLUM	1
Greenling (unident.)	GREE	7:	Spiny cheeked starsnout poacher	SSPO	1
Kamchatka flounder	KAMC	1	Starry flounder	STAR	142
Kelp greenling	KGRE	8	Sturgeon poacher	STUR	35
Longhead dab	LDAB	4	Surf smelt	SURF	14
Longsnout prickleback	LSPB	4	Threaded sculpin	S-2	30
Masked greenllng	MASK	45	Threesplne stickleback	3ST	3
Pacific cod	PCOD	2,119	Tubenose poacher	TUBE	354
Pacific halibut	HALI	102	Walleye pollock	POLK	13,377
Pacific herring	HERR	708	Warthead (Greenland) sculpin	WASC	
Pacific sandfish	TRIC	1,610	Whitespotted greenling	WGRE	10:
Pacific sand lance	SANL	62,211	Yellow Irish Lord	YEIL	52
Pacific staghorn sculpin	STAG	227	Yellowfin sole	YELS	4,706
Pacific tomcod	TOMC	1	Unidentified		39
Padded sculpin	PADS	1			
Total					92,841

Table 5.6. Abundant fish species (> 10% of catch) in the NANZ.

Fish	Catch Composition (%)							
	Bottom[1] Trawls		Midwater[2] Trawls		Gill[3] Nets		Beach[4] Seines	
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Yellowfin sole	32	46						
Rock sole	23	36						
Sand lance	10		80	46				
Pollock			16	21	16	32		
Herring				26				
Pacific cod					15	21		
Rainbow smelt					14		20	
Pac. staghorn sculpin							13	37
Chum salmon							27	10
Starry flounder								31
Totals: No.	14,413		76,131		544		920	
kg.		1,412		595		201		45
Effort (sets)	166		107		62		63	

[1] Combined gears: TRY1, BT-1, Misc. (see Table 5.3 for gear codes).

[2] Combined gears: M-3, M-4, Misc.

[3] Combined gears: GN-S, GN-B, GNXS, GNXB, Misc.

[4] Combined gears: BS-1, BS-3.

Additional information about the composition of species collected by different gear types (and in different years) is provided by several other studies conducted in the NANZ (Tack 1970, Cimberg et al. 1984, Isakson et al. 1986). These and the present study show that the abundant species (those comprising 10% or more of biomass or numbers of catches) are as follows:

Commercial Species	Forage Fishes	Miscellaneous Residents
Pacific cod	Sand lance	Pacific sandfish
Pollock	Rainbow smelt	Whitespotted greenling
Herring	Herring	Masked greenling
Sockeye salmon	Capelin	Starry flounder
Chum salmon		Staghorn sculpin
Pink salmon		Dolly Varden
Coho salmon		Surf smelt
Yellowfin sole		Tubenose poacher
Rock sole		

It is apparent that commercial species are well represented in the NANZ.

The distributions of these species were examined in four habitat categories in the NANZ: (1) Pelagic zone, (2) Demersal zone, (3) Exposed nearshore coastlines, and (4) Protected nearshore coastlines such as lagoons:

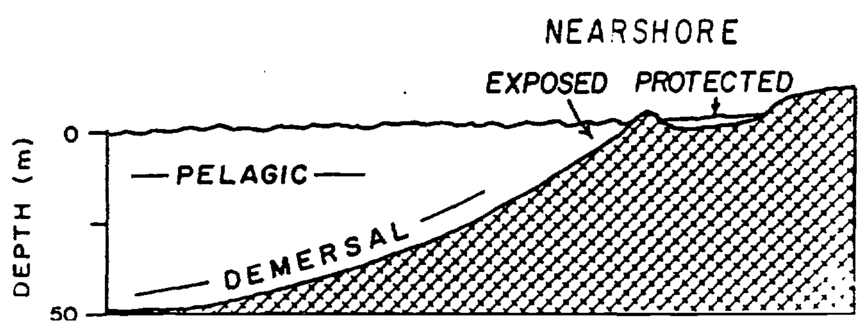


Table 5.7 lists the abundant species in each habitat; Table 5.8 provides the data upon which Table 5.7 is based. The information in

Table 5.7, Abundant fish species (>10% of catch numbers or biomass) in four coastal habitats. See text for explanation of asterisks. Sources: the present study, Tack 1970, Cimberg et al. 1984, Eggers and Fried 1984, Isakson et al. 1986.

	Dominant Fishes In Coastal Habitats			
Fish	Demersal (10-50 m)	Pelagic (20-50 m)	Nearshore (Exposed) (0-10 m)	Nearshore (Protected) (0-5 m)
Sand lance	x	x	x	x
Pacific cod	x	x	x	x
Pollock	x	x		x
Yellowfin sole	x		x	x
Rock sole	x			
Herring		x	*	*
Sockeye salmon		x	x	x
Chum salmon		x	x	x
Pink salmon		x		x
Pacific sandfish		x	x	
Whitespotted greenling		x		x
Rainbow smelt			x	x
Dolly Varden			x	x
Starry flounder			x	x
Staghorn sculpin			x	x
Capelin			*	
Masked greenling				x
Coho salmon				x
Surf smelt				x
Tubenose poacher				x

Table 5.8. Abundant fishes (>10% of catch) in various habitats in the NANZ. Abbreviations: N (number caught), W (weight).

A. PELAGIC HABITATS (20-50 m)

Fish	1984-85[1] Midwater Trawls		Purse Seine[2] 1984		Purse Seine[2] 1985		Gill[3] Net
	% N	% W	% N	% W	% N	% W	
Sand lance	80	46			28		
Pollock	16	21					
Herring		26					
Pacific cod			78	30			
Chum salmon				10			*
Pink salmon				26			
Sockeye salmon					56	95	*
Whitespotted greenling			12				
Pacific sandfish				18			
Total Catch (n)	76,131		1,853		2,223		
(kg)		595		15.5		598	
Effort (sets)	107		21		29		

[1]Gear: M-3, M-4, misc.

[2]Isakson et al. (1986): Transects 4-6, offshore Stations 0-2 (20-50 m).

[3]Eggers and Fried (1984): ADFG test fishery off Port Moller.

*See text.

Table 5.8 **(cont'd)**

B. DEMERSAL HABITATS (10-50 m)

Fish	1984 Gill Net[1] % N	% W	1984-85 Bottom Trawls[2] %% N	W	1982[3] Trvnet Trawl % W	1984[4] Otter Trawl % N	% W
Yellowfin sole	15		32	46	55	44	64
Rock sole	47		23	36	29	29	14
Pollook		54					
Pacific cod	13'	32				21	
Sand lance			10				
Total catch (n)	179		14,413			1,420	
(kg)		119		1,412	1,422		54
Effort (sets)	7		166		79	30	

[1]Gear: GN-B.

[2]Gear: TRY1, BT-1, Misc.

[3]Cimberg et al. (1984).

[4]Isakson et al. (1986): Transects 4-6, Stations 2 and 3.

Table 5.8 (cont'd)

C. NEARSHORE HABITATS - EXPOSED COASTLINE (0-10 m)

Fish	1984-85[1] Gill Nets		1984-85[2] Beach Seine		1984-85[3] Trawl		Beach Seine[4] 1984	1985	Tow Net[4] 1984	Purse Seine[4] 1985
	% N	% W	% N	% W	% N	% W	% N	% N	% N	% N
Chum salmon		15	27	10				24		28
Rainbow smelt	21		20					12	25	26
Staghorn sculpin	19	18	13	17						
Sand lance					11		94	51	72	12
Dolly Varden		14								
Pacific cod	16									
Starry flounder		18		13						
Pacific sandfish	1	2								
Yellowfin sole					33	69				
Sockeye salmon										27
Herring*										
Capelin*										
Total catch (n)	357		920		6,629		35,122	16,266	27,979	2,732
(kg)		81		45		388				
Effort (sets)	47		63		94		47	41	40	34

[1]Gear: GNXS, GNXB.

[2]Gear: BS-1, BS-3.

[3]Gear: TRY1.

[4]Isakson et al. (1986).

*See text.

Table 5.8 **(cont'd)**

D. IZEMBEK LAGOON

Fish	Gill Net[1]		Fyke Net		Beach Seine[2]		1904 Beach Seine[3]		1985 Beach Seine[3]		Otter Trawl[3]		Purae Seine[3]		Pushnet[4]	Seine	Gill Net
	% N	% W	% N	% W	% N	% W	% N	% W	% N	% W	% N	% W	% N	% W	% N	% N	% N
Chum salmon	10				85	26				11			30	12			
Staghorn sculpin	62	62 16		25		68	14	35								61	43
Sand lance							46		95	60	49						
Dolly **Varden**		13								10							
Masked greenling				18											19		
Whitespot greenling				19													22
Greenllng **unident.**			17														
Pollook			32														
Tubenose poacher			28												56	12	
Starry flounder												60					
Coho salmon													16	48			
Sockeye salmon													49	37			
Pacific cod											25						
Rainbow smelt								13									
Surf smelt							21	41									
Total **catch (n)**	39		466		171		044		4,443		1,040		62		4,169	466	403
(kg)		19		9		3		20		9		26		1			
Effort **(sets)**	5		6		6		13		4		12		3		193	29	

[1]**Gear:** GNXS.

[2]**Gear: BS-3.**

[3]**Isakson** et al. **(1986):** Transect 6; Stations **5-11.**

[4]**Tack (1970).**

Table 5.8 (cont'd)

E. PORT MOLLER

Fish	Tow Net[1]		Otter Trawl[1]		Purse Seine[1]		1984 Beach Seine[1]		1985 Beach Seine[1]	
	% N	% W	% N	% W	% N	% W	% N	% W	% N	% W
Sand lance	94	94			35	33	99	52	30	46
Yellowfin sole			79	80						
Chum salmon					12			37	58	29
Sockeye salmon					43	34				
Rainbow smelt						14				
Pink salmon									12	
Herring*										
Total catch (n)	9,848		3,818		1,643		30,856		15,940	
(kg)		18		147		20		178		59
Effort (sets)	14		16		14		15		24	

[1] Isakson et al. (1986).

*See text.

Tables 5.7 and 5.8 is thought to provide a reasonable overview of fish distribution trends in the NANZ because it is a composite of a large sampling effort in time and space, and the data were obtained using a variety of gear, each one of which is typically selective for certain species or size classes of fish.

The most prominent features of Table 5.7 are that many of the abundant species are distributed throughout the NANZ, and that the diversity of fishes increases in nearshore habitats. Six species were both abundant and widely distributed, being ranked as abundant species in at least three of the four habitats: sand lance, Pacific cod, pollock, yellowf in sole, sockeye salmon and chum salmon. A brief description of the fishes in each habitat follows.

5.6.2.1 Pelagic Zone (20-50 m depth range)

The pelagic fish community generally refers to species in the watercolumn that are not closely associated with either the seafloor or the very shallow waters adjacent to the shoreline. In the NANZ, pelagic fishes were caught by midwater trawl, purse seine, and surface gill net in waters 20-50 m deep. Abundant species in this zone were salmon, sand lance, young-of-year cod (pollock and Pacific cod), herring, and two other species not normally thought of as being pelagic--whitespotted greenling and Pacific sandfish (Table 5.8).

Salmon are abundant in the NANZ during two phases of their life cycle--smolts migrate through the study area as they leave Bristol Bay, and adult salmon migrate back through the area as they return to spawn in Bristol Bay streams. Cod young-of-year, particularly pollock, were abundant in the offshore portions of the study area and, together with jellyfish, were often the only organisms caught in midwater trawls in the NANZ. Sand lance were also present, but their overwhelming contribution to pelagic fish catches was due to a few samples from dense schools of fish. (Two midwater trawls caught a total of 47,000 sand lance, equaling 50% of all fish caught during this study.)

5.6.2.2 Demersal Zone (10-50 m depth range)

Two flatfishes (yellowfin sole, rock sole) and two semi-demersal species (pollock, Pacific cod) dominated the demersal fishes in the NANZ (Tables 5.7 and 5.8). These same species also characterize the demersal fish community throughout most of the southeastern Bering Sea shelf (Table 5.4).

Sand lance are also members of this community, though large numbers were not caught in bottom trawls. This species, which was abundant in the pelagic zone (see above), burrows into bottom sediments at night and thus would be equally abundant in the demersal zone. Our low catches could have been caused by one or more of several factors: (1) sand lance distribution is very patchy and schools could have been missed by the bottom trawls, (2) bottom trawls may not catch them efficiently, and (3) trawling was not conducted at night, and sand lance are near the seafloor only at night.

5.6.2.3 Nearshore Zone - Exposed Coast (O-10 m)

The nearshore zone has been sampled by a variety of gear (gill net, tow net, purse seine, bottom trawl, beach seine). Abundant species here generally include those occurring in the nearby pelagic zone (sand lance, salmon, Pacific sandf ish) and demersal zone (yellow fin sole, Pacific cod). Additional species that *are* abundant at various times of the year include rainbow smelt, Dolly Varden, starry flounder, and staghorn sculpin (Table 5.8). Two other species, herring and capelin, were not abundant in collections in this study but are known to spawn in the study area and migrate through in large schools (Barton 1979).

5.6.2.4 Nearshore Zone - Protected Coasts

Two semi-enclosed bodies of water, Izembek Lagoon and Port Moller, have been studied sufficiently that their fish fauna can be characterized. Results from these studies may suggest which species use other lagoons and bays in the NANZ.

Izembek Lagoon (O-5) m). This lagoon supports a diverse assemblage of year-round residents and summer transients (Tack 1970, Smith and Paulson 1977, Isakson et al. 1986 , the present study). Over 30 species have been collected in the lagoon; 14 of these comprised 10% or more of the total catch in the above studies (Table 5.8). The principal residents were the staghorn sculpin, tubenose poacher, whitespotted and masked greenlings, and starry flounder. The most abundant summer transients were salmon juveniles and adults, sand lance, Dolly Varden, pollock juveniles, Pacific cod, rainbow and surf smelts (Tables 5.7 and 5.8). Herring and capelin may pass through the lagoon as well. Of all these species, only four (masked greenling, coho salmon, surf smelt, tubenose poacher) were not abundant in samples from pelagic, demersal or exposed nearshore zones.

Port Moller (O-40 m). This very large waterbody contains a diverse array of aquatic habitats, from expansive tidal mudflats in Nelson Lagoon to embayments 40 m deep. Isakson et al. (1986) sampled Port Moller with a variety of gear and caught primarily sand lance, salmon, yellowfin sole, and rainbow smelt, all of which are common in other areas of the NANZ (Tables 5.7 and 5.8).

5.6.3 Seasonal Abundance

Fish abundance in the NANZ can be characterized as (1) dominated by demersal fishes, which are probably present in similar concentrations farther offshore, and (2) subject to large, but sporadic, pulses of forage fishes in spring and summer. Fish CPUE (catch per unit effort) and BPUE (biomass per unit effort) are' summarized in Table 5.9 and examined below by season and habitat. More detailed CPUE and BPUE estimates are listed by species and gear type in Appendix 5.1 and by season in Appendix 5.2. Sample sizes are also listed in these appendices.

5.6.3 .1 Demersal Zone

In the eastern Bering Sea, many demersal fishes are reported to undergo a seasonal migration from deep overwintering areas on the outer shelf or slope to shallower waters of the shelf during summer (e.g., Hood

Table 5.9. Fish catch per **unit effort (CPUE)** and biomass per unit effort **(BPUE),** all sites and dates combined.

Habitat	Gear	CPUE	BPUE
Pelagic			
- larval fish	Bongo		1.0 mg/m^3
- non-larvae	M-4	0.01 $fish/m^3$	0.07 g/m^3
Benthic			
- small trawl	TRY1	0.04 $fish/m^2$	2.0 g/m^2
- large trawl	BT-1	0.04 fish/m2	10.6 g/m^2
Nearshore			
- gill net	GNXS,GNXB	0.8 fish/h*	180.0 g/h*
- beach seine	BS-1,3	15.0 fish/haul*	461.0 g/haul*

*Weighted averages.

'See gear codes in Table 5.3.

and Calder 1981). Some supportive evidence for this general pattern was observed in this study--fish biomass in 1985 in the NANZ was high in summer and low in winter, although there was little such difference the previous year (Fig. 5.7a).

The winter data suggest that migration patterns may be different among different age groups. Fish numbers in winter remained at about summer levels even though biomass decreased. This was apparently caused by the winter exodus of many (but not all) large fish and the movement of smaller individuals into the shallows to overwinter (discussed further in Section 5.6.5, this report).

Estimates of biomass of demersal fishes in this study were similar to those reported in previous studies in the NANZ, ranging from about 2-4 g/m2 when small bottom trawls were used to sample fish (Table 5.10). For comparative purposes, we used a larger bottom trawl (gear code BT-1) on four occasions to determine if some fish were able to avoid being captured by the smaller gear. The larger trawl caught about five times more fish biomass than the small trawl (Table 5.101, but the numbers of fish caught by the two trawl sizes were generally similar (Fig. 5.7a), thus indicating that small trawls missed some of the larger fish in the population. The biomass of demersal fishes thus appears to be under-represented by the small-trawl data. It is not known if this bias applies equally throughout the NANZ, because the large trawl was not used in water less than 50 m deep.

In the deeper waters of the eastern Bering Sea, the estimated biomass of demersal fishes (based on catches by large trawls) is usually about 20-40 g/m^2 (Table 5.10). Although this indicates that the biomass of demersal fish in the NANZ is relatively low, there are two reasons why this conclusion may be premature. First, the NMFS trawl surveys in shallow waters (20-50 m deep) around Bristol Bay (of which our study area is a part) caught a biomass of demersal fish (29.3 g/m^2) which is similar to that in deeper waters, thus suggesting that our estimates, even with the large trawl, are too low (Table 5.10). Second, the NMFS surveys also found that the biomass of demersal fish in and adjacent to the NANZ is locally variable (12.5-40 g/m2 = 125-400 kg/ha, see Fig. 5.4), thus our results with the large trawl may simply reflect the small sample size with this gear (n=4).

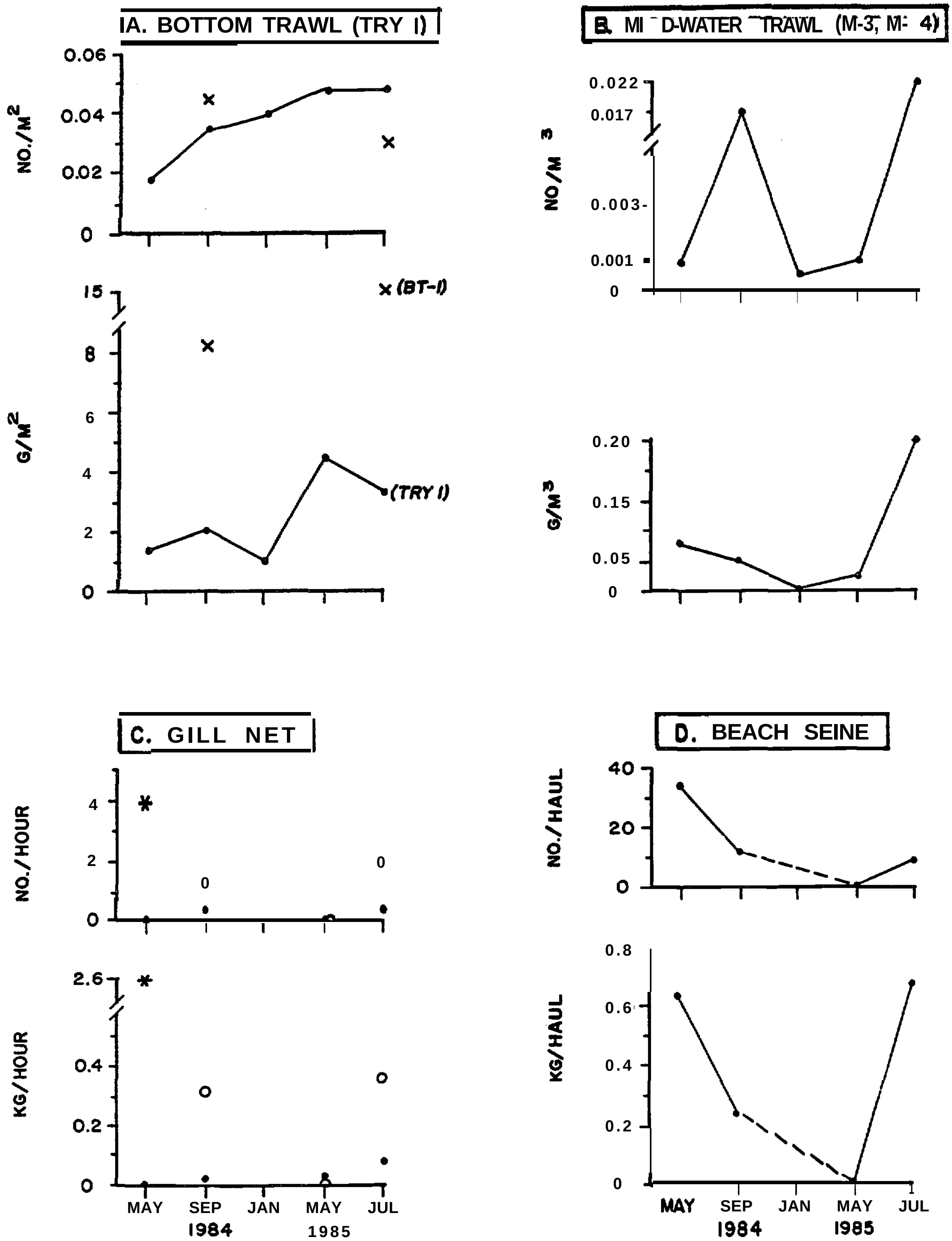


Figure 5.7. Seasonal CPUE and BPUE by four gear types in the NANZ study area, Alaska, species combined. Symbols: x (large bottom trawl BT-l), * (offshore gill net, bottom set), . (nearshore gill net, surface set), o (nearshore gill net, bottom set).

Table 5.10. Biomass of demersal fishes (species combined) caught by large and small bottom trawls in the NANZ and NMFS Subarea 1 in the eastern Bering Sea.

Year	NANZ Small Trawl	NANZ Large Trawl	NMFS Subarea 1 Old[e] Large Trawl	NMFS Subarea 1 New[f] Large Trawl
1978			28.7	
1979			29.1	14.5
1980			24.1	20.8
1981			24.7	26.5
1982	4.3[a]		50.0	38.6
1983				44.1
1984	1.5[b]		39.4	36.7
1984-85	2.0[c]	10.6[d]		
1985				23.7
Means	2.6	10.6	32.7	29.3

[a] Cimberg et al. 1984, Trynet trawl (18' mouth, L. Thorsteinson, pers. comm.).

[b] Isakson et al. 1986, Trynet trawl (24' mouth), Transects 1-6.

[c] This study, Trynet trawl (16' mouth) (TRY1).

[d] This study, 83/112 trawl (BT-1).

[e] Bakkala et al. 1982, 1985; Umeda and Bakkala 1983; Bohle and Bakkala 1984; Sample et al. 1985. Miscellaneous large trawls were used, including the 83/112.

[f] Bakkala, pers. comm. New Subarea 1 = shallow waters (20-50 m) around Bristol Bay from Unimak Island to Nunivak Island.

5.6.3.2 Pelagic Zone

Fish caught in the pelagic zone of the NANZ consist of two gear-related size components--larval fish (caught by zooplankton net) and small to large fish (caught by midwater trawl and surface gill net).

Densities of larval fishes in the NANZ were low, averaging only 1 mg/m^3 (in 91 oblique bongo net tows) which is equivalent to about 1-2 $larvae/m^3$. Highest densities were recorded in May 1985 (4 mg/m^3) and July 1985 (5 mg/m^3).

Theabundance of larger pelagic fishes was also low, due in part to gear limitations and to the low intensity of sampling. Juvenile and adult salmon, for example, are not particularly vulnerable to the gear used in this study (juvenile salmon were specifically targeted in the companion OCSEAP study by Isakson et al. 1986). Other schooling species such as herring and sand lance are highly clumped in time and space, and precise estimates of their abundance requires a much more intensive sampling effort than was possible in this study. Despite these considerations, the ship's 38 kHz was monitored during all mid-water trawls, and it only occasionally identified fish schools that the trawls missed. Further, even if the mid-water trawls had accurately sampled pelagic fishes during the sampling periods, large pulses of fish activity could have occurred between sampling cruises (e.g., one such probable pulse was the spawning migration of herring through the NANZ in June, a time not sampled during this study).

CPUE and BPUE of trawl-caught fish were generally only about 0.001 fish/m3 and 0.05 g/m^3, respectively, except during summer periods when high but sporadic catches of sand lance were made (Fig. 5.7b). These estimates are probably biased by two opposing methodological problems: (1) the estimates are biased upward because mid--water tows were generally made at depths where sonar indicated the highest concentrations of fish to be, but (2) the values are also biased downward because small individuals of the principal species caught (sand lance and pollock young-of-year) were not effectively retained by the mesh of the trawl used. The magnitudes of these biases are not known.

Isakson et al. (1986) used a small-mesh purse seine to sample fishes in the watercolumn in the study area and obtained an average biomass estimate of 0.02 g/m^3. Although this value is similar to our estimate (excluding our large catches of sand lance), the similarity is coincidental because the two gear types sampled different parts of the fish community. Our mid-water trawl generally caught sand lance and small pollock at offshore stations (20-90 m depths), usually at tow depths 10 m or more below the water surface. In contrast, their purse seine sampled surface waters (O-l 1 m) closer to shore (10-30 m depths) and caught a variety of fishes, including some adult salmon.

In May 1984, large gill nets (gear code GN-S) were used to sample pelagic fishes in offshore waters of the NANZ (at the 20-and 50-m stations). Catches of fish in surface waters were almost nil--only a single fish was caught in 7 gill net sets (= 48 h fishing time). The timing of this sampling effort contributed to its low catches because it was conducted too early in the season to catch adult salmon returning to Bristol Bay. Herring, however, migrate into the NANZ about this time to spawn, but their pre-spawning aggregations were highly localized and not in the few areas sampled.

5.6.3.3 Nearshore Zone

Fish catches along the NANZ shoreline were surprisingly low. Average gill net and beach seine catches consisted of only 1 fish/h and 15 fish/haul, respectively (Fig. 5.7c,d). Isakson et al. (1986) report a considerably higher beach seine CPUE in the NANZ (mean = 815 fish/haul in their Transects 4 and 6), largely due to sporadically high catches of sand lance and juvenile chum salmon.

Gill nets were also used in May 1984 in nearshore and offshore areas. Catches indicated a low abundance of fish in both areas. Nearshore catches were zero (n=6 sets), offshore surface catches were 0.02 fish/h (n=7 sets), and offshore bottom catches were 4 fish/h (n=7 sets). Even the latter rate must take into account that the offshore nets were 6 times larger than the nearshore nets, so it is to be expected that the offshore nets would catch more fish.

5.6.4 Echosounder Analyses

Hydroacoustic sampling was conducted during most fish trawling efforts and also during continuous transects conducted for shipboard censusing of seabirds and marine mammals. These hydroacoustic surveys provide information about general patterns of fish distribution at far more locations that could be sampled by nets. Further, they showed that conventional sampling gear was not missing large concentrations of pelagic or semi-demersal fishes (such as the dense concentrations of pollock which occur in deeper waters beyond the study area).

5.6.4.1 Comparison of Echosounder and Trawl Data

Before the hydroacoustic data can be interpreted, it is necessary to examine the relationships between the hydroacoustic data and fish catches by net. For the 61 midwater trawls (M-4) examined, there were significant positive correlations between estimates of echo-intensity and the abundance of fish caught (Table 5.11). But the biomass of fish in midwater trawls was also positively correlated with the biomass of jellyfish. Thus, it is likely that the higher codes of echo-intensity represent increases in both fish and jellyfish abundance in the mid-water zone. For the 33 bottom trawls (TRY1) examined, there was no significant positive correlation between echo-intensity and numbers or biomass of bottomfish (Table 5.1 1). This probably reflects the fact that most demersal species in the study area were flatfishes which usually lie directly on the seafloor and thus are not highlighted by echo-intensity.

5.6.4.2 Regional Patterns

A total of 655 10-min segments of 38-kHz echosounder tapes, representing 2326 km of the ship's track was examined to provide an overview of fish distributions in the study area. Mean values of echo-intensity were highest during summer periods and low in winter and spring (Table 5.12), which is in agreement with data obtained by other gear used in this study.

Table 5.11. Relationships between fish catches in midwaterand bottom trawls and echosounder intensity (38 kHz) at the trawl depth in the NANZ study area.

	Correlation Coefficient	P
MIDWATER TRAWLS		
CPUE	0.28	0.05
BPUE	0.31	0.05
Mean wt. of fish	0.38	0.01
BOTTOM TRAWLS		
CPUE total fish	-0.09	NS
CPUE pelagic fish	-0.01	NS
CPUE flatfish	-0.11	NS
BPUE total fish	-0.18	NS
BPUE pelagic fish	0.02	NS
BPUE flatfish	-0.03	NS

Table 5.12. Echosounderrecords (38 kHz) from the NANZ study area coded for echo-intensity. Grand mean refers to the echo-intensity standards which ranged from 0 to 9.

Cruise	No. 10-min Segments	Total Distance Covered (km)	Grand Mean	SD
May 1984	82	239	0.4	0.6
September 1984	172	559	2.1	1.0
January 1985	70	259	1.2	0.9
May 1985	217	805	1.5	0.8
July 1985	114	464		
	655	2326		

For each of the five sampling periods the mean and maximum values of the hydroaooustic data are stylistically illustrated in Figures 5.8 and 5.9, where data obtained *along* transect lines have been expanded to cover both sides of the transect. As previously described, the mean value is the average of values obtained in the watercolumn during each **10-min** segment of echosounder recording. The maximum value is the largest value obtained anywhere within the watercolumn.

The mean echo-intensities (Fig. **5.83** show the broad-scale distribution of fishes (and probably jellyfish). During most cruises, they tended to be homogeneously distributed throughout the shallow waters of the study area.

The maximum echo-intensities (Fig. 5.9) indicate a more patchy distribution of fishes, which is somewhat similar to the distribution of zooplankton during the same periods (see Section 4.0, this report). Locations of maximum fish abundance were **seasonally** variable and without consistent spatial trends within the limits of the study area.

5.6.5 Species Accounts

The temporal and spatial distributions and food habits of the abundant species are described in the following sections. Emphasis is placed on the most abundant species in the NANZ (sand lance, yellowfin sole). Life history highlights of other common species **(pollock,** rock sole, salmon, herring), and only a few details are presented for the less abundant species (rainbow smelt, capelin, Pacific cod, halibut, and others). Because of the large number of species involved, the fishes have been divided into four functional groupings: forage fish, salmon, demersal fishes, and nearshore residents.

An overview **of** the **uses of** the study area by the various species is summarized in Table **5.13.** Major uses for all groups involve feeding and migration. A relatively small degree of spawning occurs in the **NANZ** by herring) capelin, and nearshore residents. In winter when many species have departed, the NANZ is inhabited by several demersal fishes as well as the resident species that remain year-round.

Table 5. 13. General patterns of fish use of nearshore waters along the northern Alaska Peninsula.

Species	Use of Study Area			
	Spawn	Feed	Migrate	Overwinter
Forage Fishes				
Sand lance	?	X	X	
Herring	X	X	X	
Capelin	X	X	X	
Rainbow smelt	?	X	X	
Pollock young-of-year		X		
Salmon				
Adults		X	X	
Juveniles		X	X	
Bottomfish				
Yellowfin sole	?	X	X	X
Rock sole	?	X	X	X
Pollock		X	X	
Pacific cod		X	X	
Lagoon and Nearshore Residents				
Greenling	X	X	X	X
Poachers	X	X	X	X
Sculpins	X	X	X	X

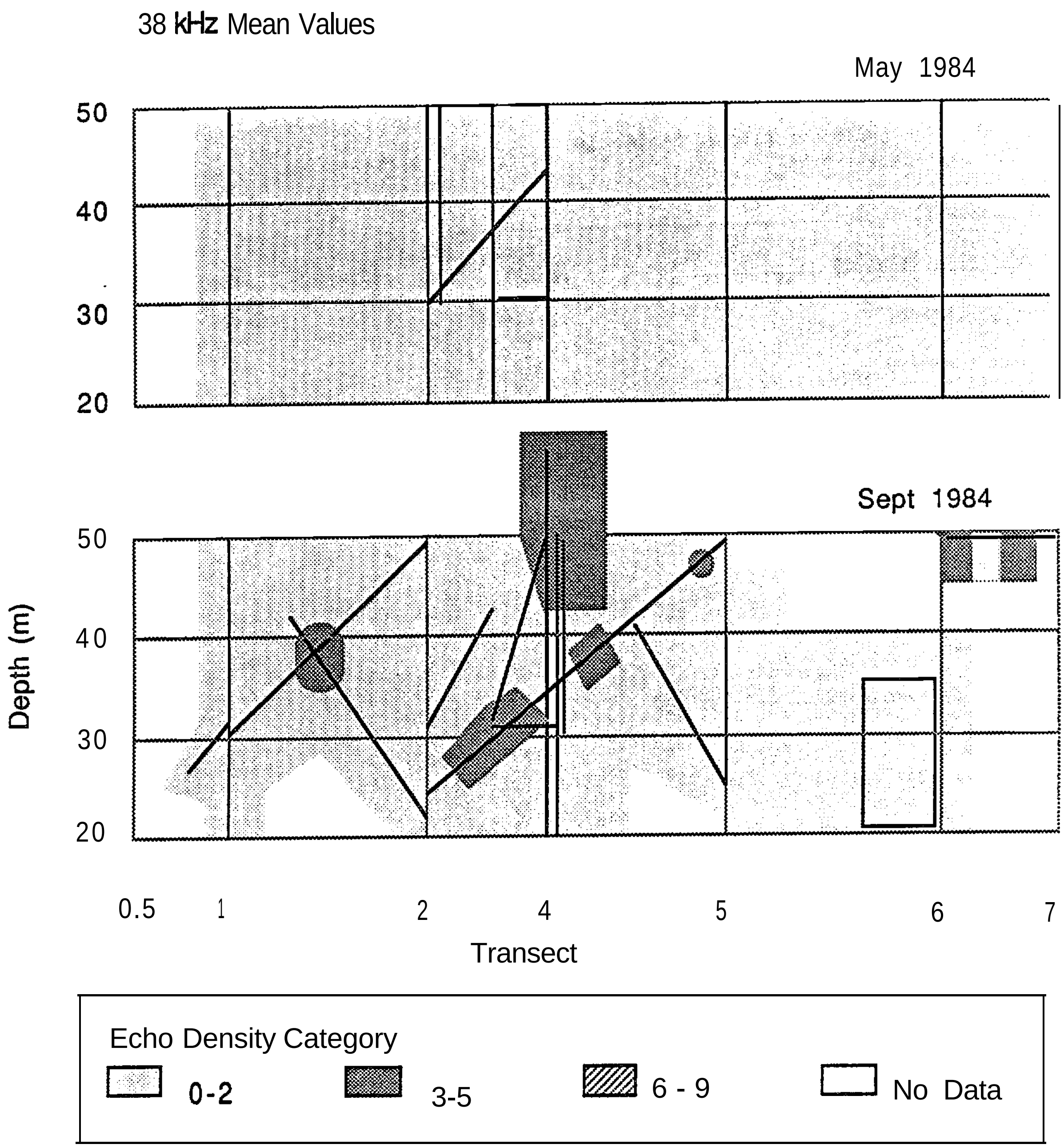
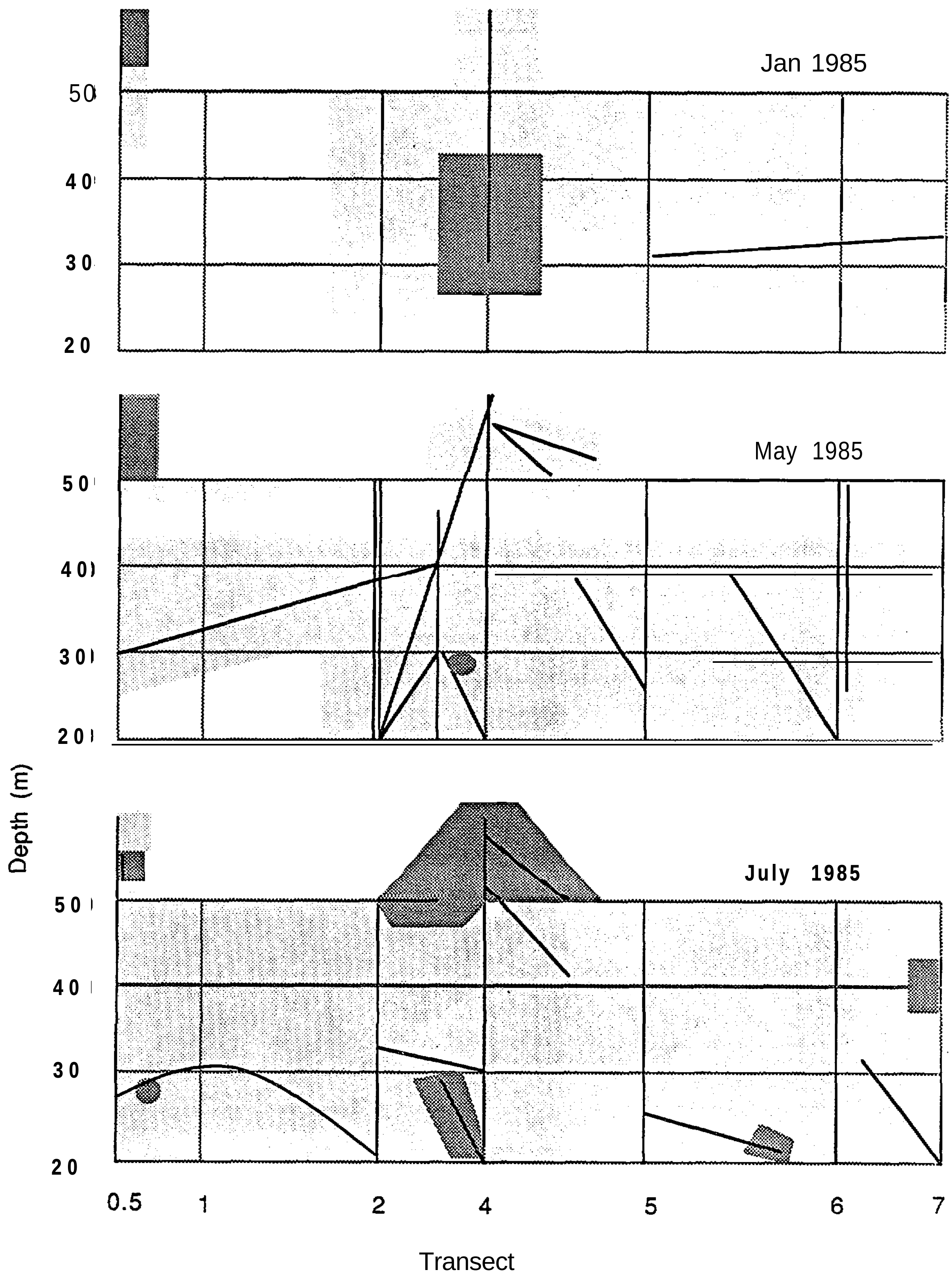


Figure 5.8. Stylized map of the NANZ study area, Alaska, showing the mean hydroacoustic echo-intensity (38 kHz) in the watercolumn during five cruises. Echosounder transects (dark solid lines) have been expanded to both sides of the transect line.

38 kHz Mean Values



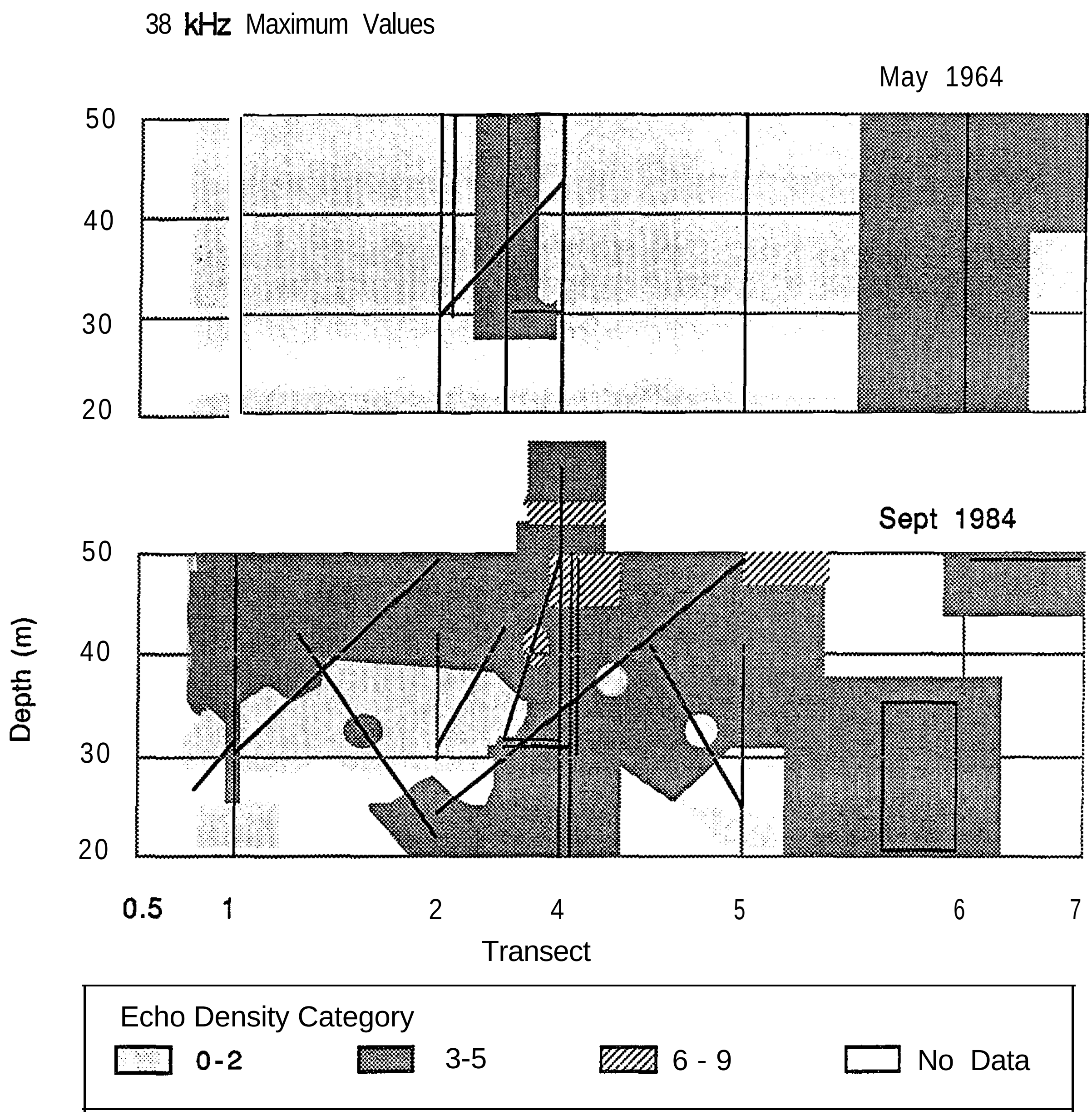
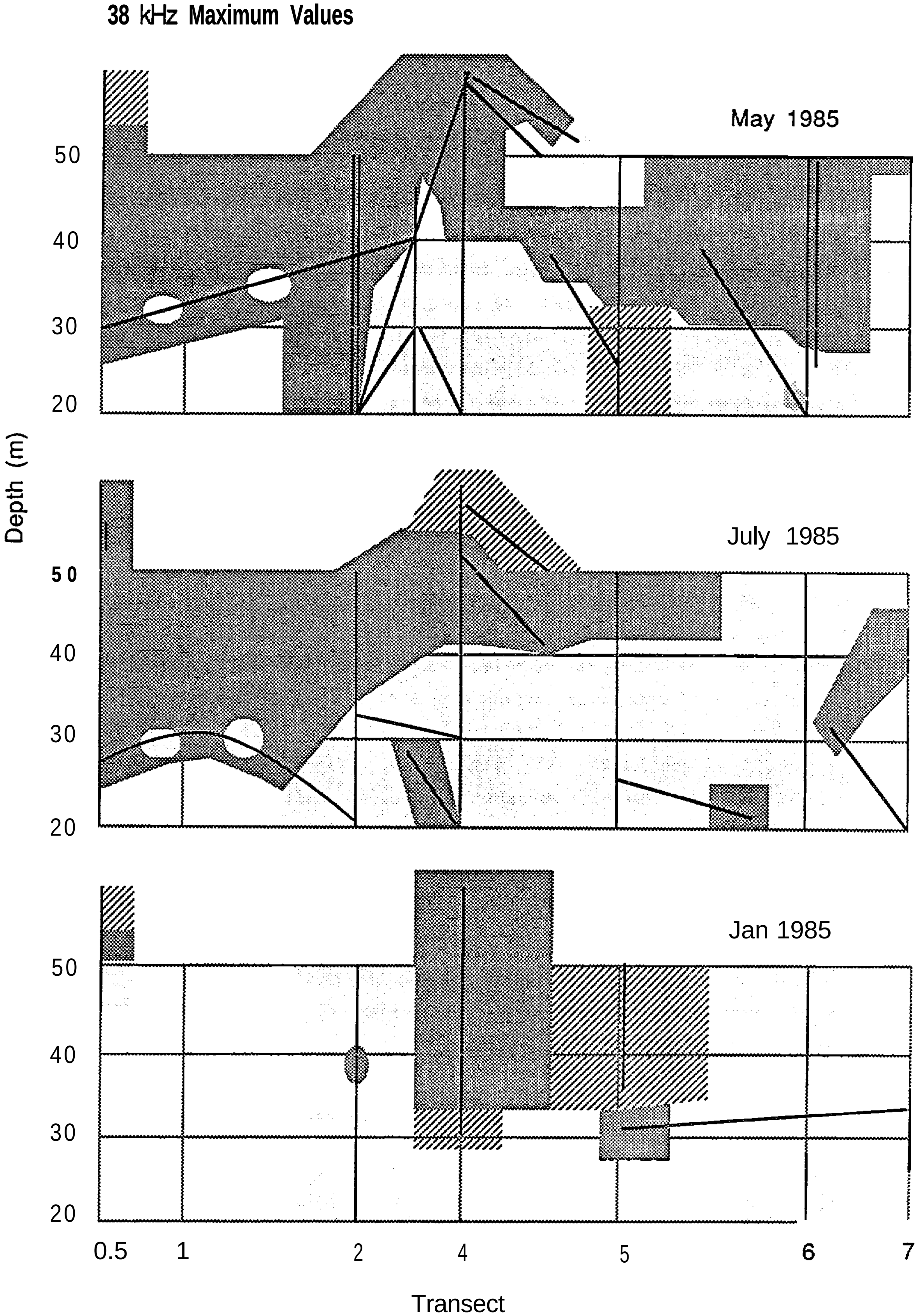


Figure 5.9. Maximum hydroacoustic value (38 kHz) in the watercolumn during five cruises in the NANZ study area, Alaska. Echosounder transects (dark solid lines) have been expanded to both sides of the transect lines.


38 kHz Maximum Values
May 1985
July 1985
Jan 1985
Depth (m)
50
40
30
20
50
40
30
20
50
40
30
20
0.5
1
2
4
5
6
7
Transect

5.6.5.1 Forage Fishes

The term 'forage fish' refers to species that are abundant, small, and significant in the diets of other consumers. Important forage species in the NANZ include sand lance, herring, capelin, rainbow smelt, and young-of-year pollock.

From early spring to late summer, there is a series of activity pulses as each forage fish species enters the area for various life history functions (Fig. 5.10a). Some species spawn in nearshore habitats, producing large numbers of eggs and young which later enter the study area. Other species feed in nearshore waters and may occur in dense schools. All species may be locally abundant at different times through the summer as they migrate to and from spawning, feeding,and overwintering areas. The net result is an abundant and presumably dependable supply of food for seabirds, marine mammals, and other fishes (Fig. 5.10b).

Pacific Sand Lance. The sand lance is a seasonally abundant fish which plays an important role in the Bering Sea food web. This small fish is a key food item for many species of seabirds, marine mammals, and other fishes. Although sand lance species are harvested commercially elsewhere in the world, they have largely gone unnoticed in the northeastern Pacific Ocean. Summaries of available information have been compiled by Trumble (1973) and Macy et al. (1978). More recent information is limited but growing (e.g., Dick and Warner 1982, Pinto 1984, Pinto et al. 1984, Hobson 1986, Isakson et al. 1986). Because knowledge about sand lance is limited, this species has been examined in more detail than other species in this report.

Sand lance in our area probably spawn in late fall or winter (Macy et al. 1978, Dick and Warner 1982). They may spawn intertidally (Dick and Warner 1982) or at depths of 25-100 m in areas having strong currents (Trumble 1973). These fish require particular substrate compositions for burrowing and presumably for spawning. Their adhesive eggs probably hatch in about 30 days, the exact time depending on water temperature. After the yolk sac is absorbed, the larvae become pelagic and widely distributed in the eastern Bering Sea (Fig. 5.11). Thereafter, the fish apparently

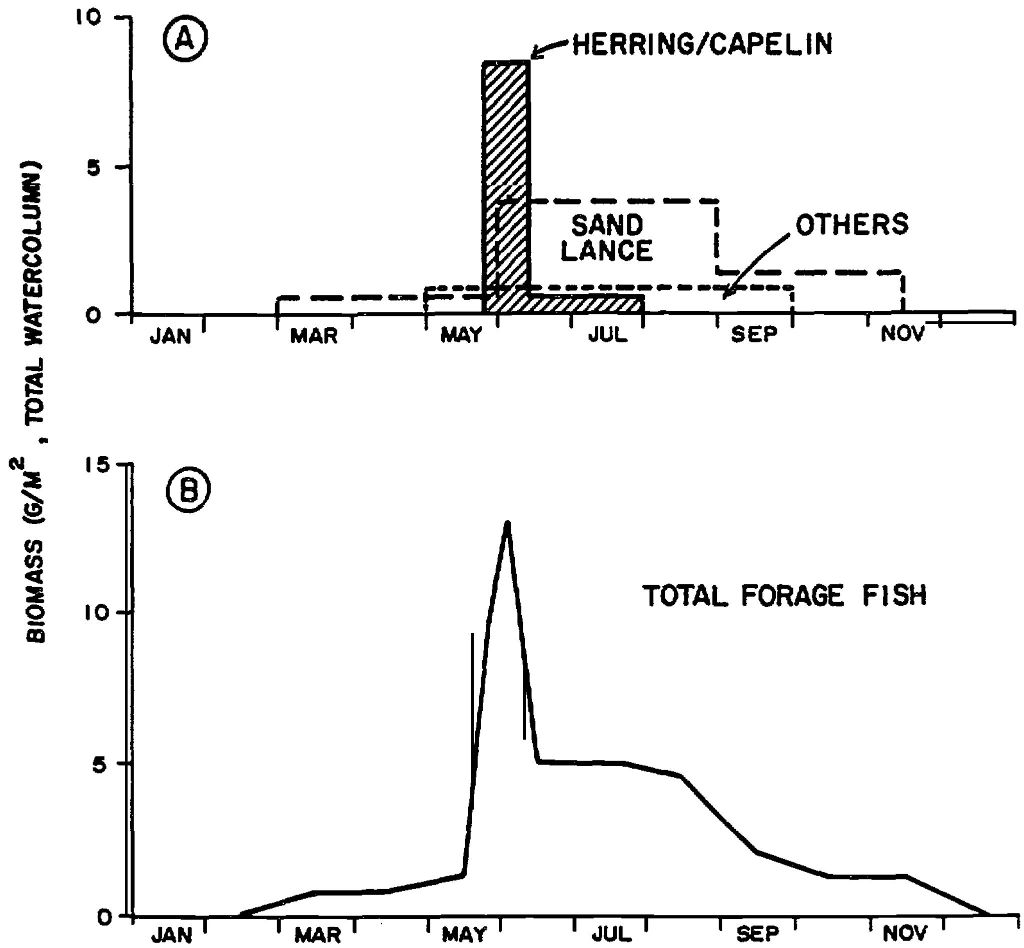


Figure 5.10. Estimated seasonal biomass of forage fishes in the NANZ study area, Alaska, 1984 and 1985 combined. Estimates are based on trawl data and assumptions outlined in Section 8.0.

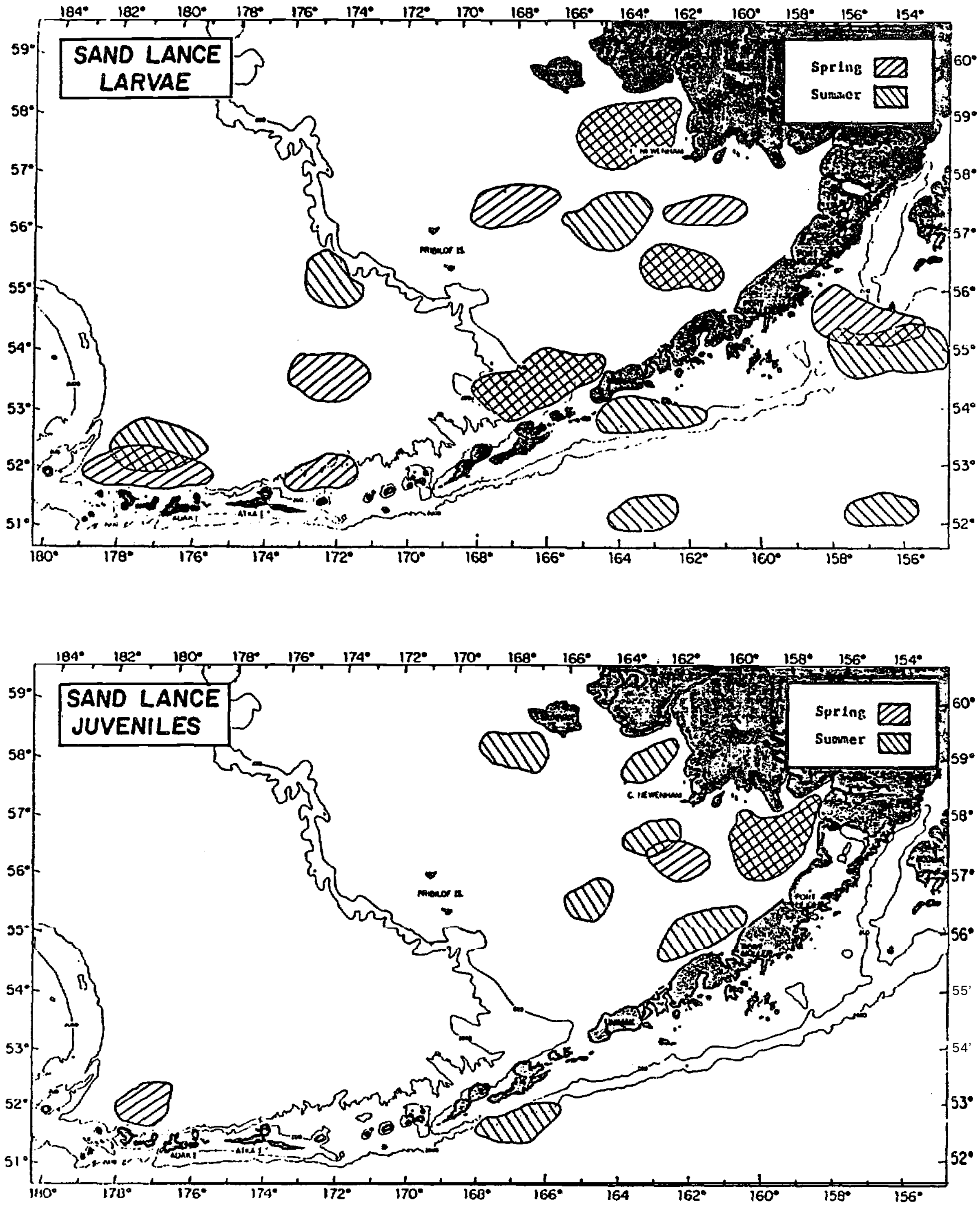


Figure 5.11. Generalized areas in which Pacific sand lance larvae (top) and juveniles (bottom) were caught by plankton nets, seine nets, and bongo nets in spring and summer, eastern Bering Sea and western Gulf of Alaska, by the NMFS. From Macy et al. (1978).

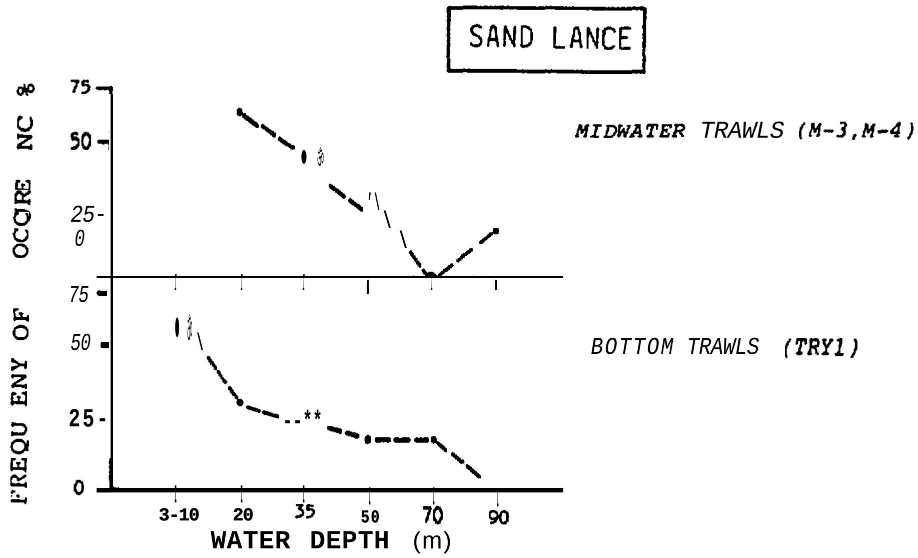


Figure 5.13. Frequency of occurrence of sand lance caught in trawls at various water depths, dates combined (January-September), in the NANZ study area, Alaska.

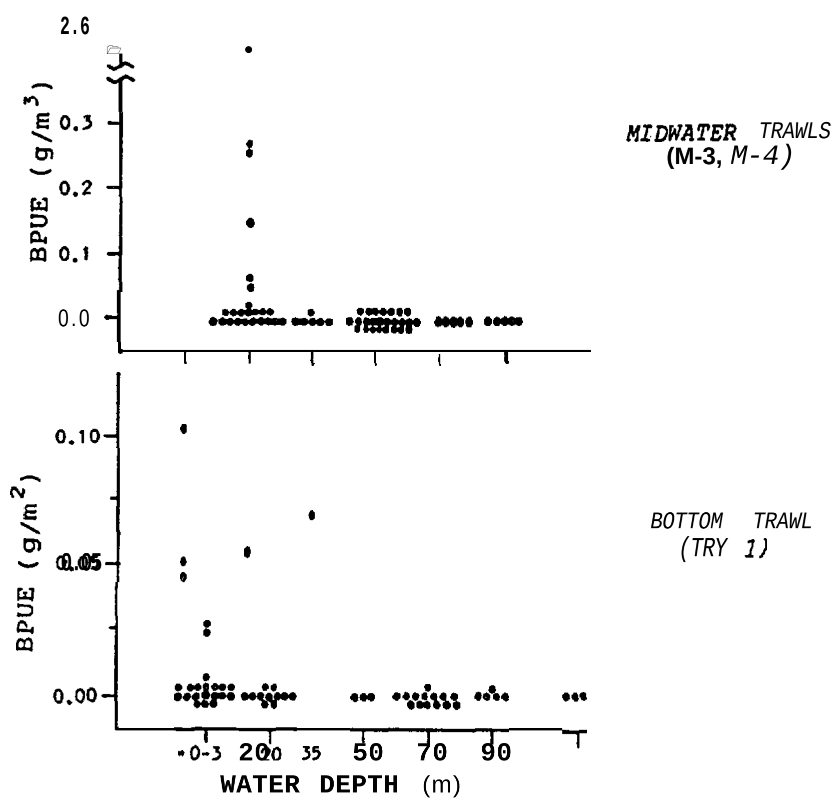


Figure 5.14. BPUE of sand lance caught in trawls at various water depths, dates combined (January-September), in the NANZ study area, Alaska. Data points represent station averages.

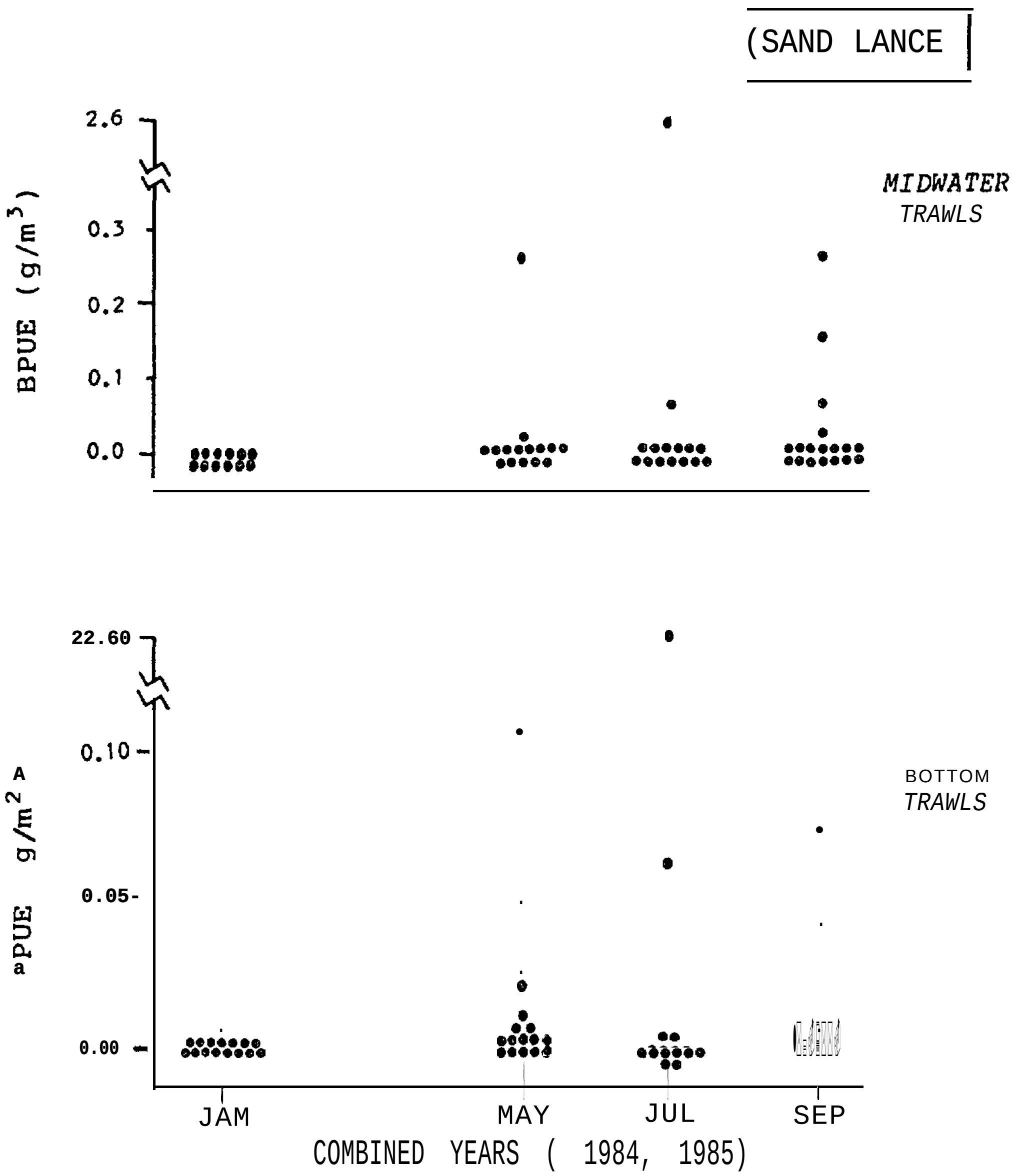


Figure 5.15. Seasonal BPUE of sand lance caught in **midwater** trawls (top) and bottom trawls (bottom), in the NANZ study area, Alaska. Data points represent station averages.

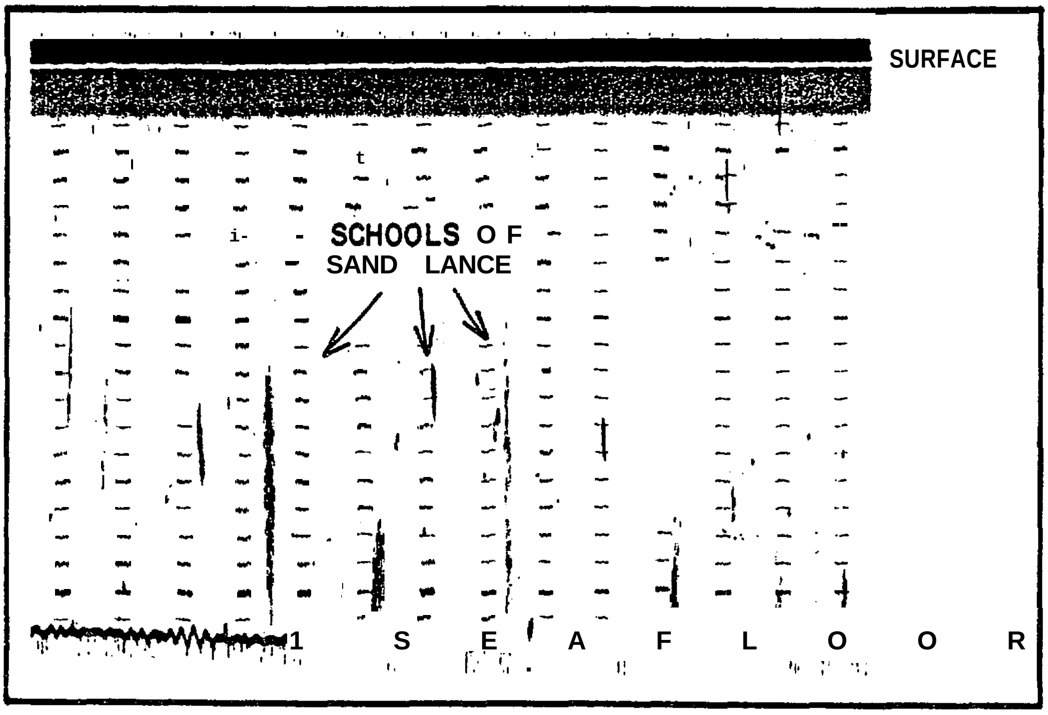


Figure 5.16. Echo-sounder record of fish schools in 26 m of water on Transect 4, July 1985, in the NANZ study area, Alaska. A 10-min trawl through this area caught over 30,000 sand lance.

accounted for most of their winter diet and copepods were eaten in summer (Table 5.14, Fig. 5.17). While feeding occurs year round, most consumption apparently occurs in winter and early spring as indicated by the degree of stomach fullness at these times, which was about four times greater than occurred in summer (Table 5.14, Fig. 5.17). This finding is in agreement with the observation by others that the main growth period for sand lance occurs in the first part of the year, February to June (Oshima 1950) or January to August (Macer 1966).

Sand lance diets were compared with the available food supply (as measured by invertebrate sampling methods described in Section 4.0, this report) to determine if the fish selected partioular prey groups. Using Ivlev's (196 1) electivity index (EI), proportions of prey groups in sand lance stomachs (% weight) were compared to proportions of the same prey groups in the watercolumn (% weight). The index has a possible range of -1 to +1, with negative values indicating avoidance or inaccessiblity of the prey item, zero indicating random selection from what is available in the environment, and positive values indicating active selection. In these calculations, jellyfish and ctenophores were excluded because they dominate the biomass of zooplankton but are not eaten by sand lance.

The results indicate that a sharp change in preferred prey occurred from winter to summer (Table 5.15). In January, sand lance consumed euphausiids in much greater proportion than their measured abundance in the watercolumn (EI= +0.8) and avoided, or could not catch, copepods (EI= -0.9). There was a transition period in May when euphausiids and copepods were eaten in proportion to their apparent availability (EI= 0) or copepods were preferred (EI= +0.4 in 1984) over euphausiids (EI= -1.0 in 1985). By July and September, sand lance consistently preferred copepods (EI= +0.3 to +0.5) over euphausiids (EI= -0.9 to -1.0). Reasons for the apparent avoidance of copepods in winter and euphausiids in summer are not known. Some possibilities include changes in prey size *or* species composition, or prey avoidance.

During all sampling periods, sand lance ate few chaetognaths and fish larvae compared with the apparent abundance of these prey groups. Electivity results for the remaining groups were mixed.

Several additional types of dietary comparisons were possible with the sand lance data, as follows:

Table 5.14. Seasonal diets of sand lance (see Appendix 5.3A for more details).

Food Item	Diet Composition (% Weight)		
	Winter [a]	Spring [b]	Summer [c]
Copepoa		26	90
Euphausiid (total)	(100)	(40)	
Thysanoessa inermis	30	18	
T. raschii	19		
misc. & unident.	51	20	
Amphipod		7	
Mysid		7	
Crustacea (unident.)		11	
Other		11	10
Ave. contents (mg)	12	12	3
Mean fish size	101	128	104
No. fish examined	9	110	169

[a]Winter (January 1985).
[b]Spring (May 1984 and 1985).
[c]Summer (July 1985, September 1984).

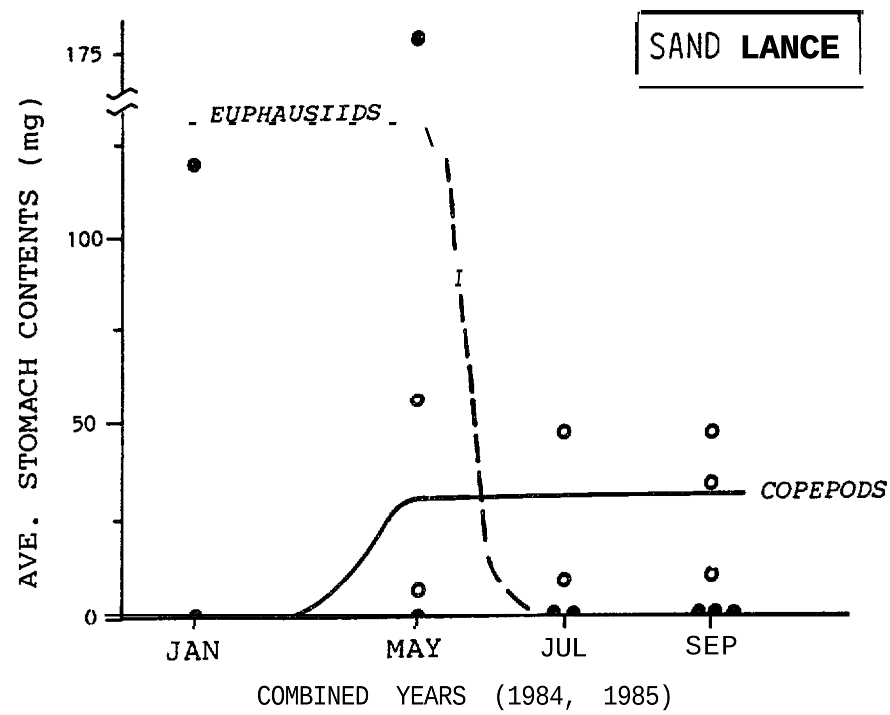


Figure 5.17. Seasonal importance of euphausiids and copepods in the diets of sand lance in the NANZ study area, Alaska. Each data point represents one size or site-specific group of fish listed in Appendix 5.3A.

Table 5.15. Comparisons of proportions of zooplankton in the diets of sand lance and in the water column. Gelatinous zooplankton (jellyfish, ctenophores) are not eaten by sand lance and have therefore been excluded from these comparisons.

	Electivity Index (EI)[a]				
	Jan. 1985	May 1984	May 1985	July 1985	Sep. 1984
Euphausiids	0.8	0.0	-1.0	-0.9	-1.0
Copepods	-0.9	0.4	0.0	0.3	0.5
Chaetognaths	-1.0	-0.8	-1.0	-0.9	-0.7
Fish larvae	-0.7	-0.7	-1.0	-0.5	-1.0
Decapod larvae	-1.0	-1.0	0.5	-0.2	-1.0
Hyperiid amphipods	-1.0	0.3	-1.0	0.0	-0.2
Mysids	-0.9	0.8	0.0	-1.0	-1.0

[a] Ivlev 1961.

1. Annual Differences. Sand lance diets differed greatly between the May 1984 and May 1985 samples (Table 5.16). Euphausiids were the primary food in the former period, and copepods in the latter period. This disparity is, in large part, a reflection of the very different abundances of these prey groups in the watercolumn during the two years:

	Euphausiids (%)		Copepods (%)	
	Available	Eaten	Available	Eaten
May 1984	65	66	9	21
May 1985	2	0	48	58

Availability data *were* derived from oblique bongo net tows (see Section 4.0, this report).

2. Nearshore vs. Offshore. Sand lance were collected from two depth zones during the May and September *1984* cruises (Table 5.16). Some *dietary* differences were noted in the May *1984* collections--sand lance from Izembek Lagoon ate fewer copepods but more amphipods and polychaetes than did fish collected farther offshore at Station C (20 m), but the offshore fish had three times more food in their stomachs. The September samples also show slight differences in diet. In both cases, these differences are likely due to differences in prey distributions.

3. Fish Size. Diets of medium-sized sand lance (70-100 mm) *were* compared with those of large sand lance (101-159 mm) on two occasions (Table 5.16). The principal difference was that the smaller fish ate more copepods and had perhaps a less varied diet than the larger fish. The larger fish also had more food in their stomachs, as might be expected due to fish size alone.

Table 5.16. Sand lance diets: comparisons between years, water depths, and fish sizes.

	Years		Diet Composition (% weight) Comparisons							
			Locations				Fish Sizes			
	May	May	May 1984		September 1984		July 1985		September 1984	
	1984	1985	Lagoon	20 m	20 m	30-50 m	93 mm	126 mm	83 mm	114 mm
Copepod	21	58	*	21	88	96	93	79	96	88
Euphausiid	66		55	66				1		
Amphipod	2			2	8	1		1		8
Mysid	9		20	9						
Polychaete	*		6	*				1	1	
Chaetognath	2			2	3			5		3
Crustacean larvae	*	30	2	*	*	1	1	6	1	•
Decapod larvae		12	*		*		6			*
Other	*	0	4	*	1	2		6	2	1
Ave. contents (mg)	270	10	80	270	40	50	10	60	10	40
No. stomachs	40	24	46	40	29	32	33	30	45	29

*<0.5%

4. Prey Species. The species composition of euphausiids and copepods consumed by sand lance was examined in a subsample of fish stomachs (Table 5.17). In May 1884, the species eaten were those which characterized the zooplankton of the outer shelf of the Bering Sea (Cooney 1981). In September 1984, the dominant species eaten were those of the nearshore zooplankton community. These results reflect the changes in water masses (and their zooplankton communities) that occurred in the NANZ (see Sections 2.0 and 4.0, this report) .

Pacific Herring (Clupea harengus). Herring are very abundant in the eastern Bering Sea, with major spawning concentrations occurring in the Togiak area of northern Bristol Bay. Spawning populations in the NANZ at Port Moller (Fig. 5.18) are a relatively small part of the overall herring biomass in the eastern Bering Sea, but the study area is thought to be part of a migration corridor for herring stocks spawned elsewhere in Bristol Bay (Fig. 5.19). Scale-pattern analyses indicate that about 80% of the herring harvested at nearby Unalaska Island are from Bristol Bay (Togiak stock) with 10% from farther north (Nelson Island) and 10% from Fort Moller (Walker and Schnepf 1982, Eebida et al. 1984, Rogers and Schnepf 1985).

Schools of herring (some mixed with capelin) are most abundant from late May to mid June along the northern shoreline of the Alaska Peninsula (Fig. 5.20). They are even more abundant, however, outside our study area. Proceeding eastward along the Alaska Peninsula, springtime schools of herring and capelin increase from maximum densities of only 0.02 schools/km of coastline near Bechevin Bay to 1.7 schools/km near Port Heiden (Fig. 5.20). Furthermore, the average density of such schools along the Alaska Peninsula is overshadowed by much larger densities occurring in the Togiak area (Fig. 5.21).

Despite the use of Port Moller/Herendeen Bay by herring for spawning (average commercial harvest = 570 tons -- Schwartz 1985), few herring were caught in the NANZ by us or Isakson et al. (1986) in 1984 or 1985. Only 708 herring in total were caught in the present study, 87% of which were taken in a single midwater trawl. These fish were caught at the western

Table 5.17. Sand lance diets: species composition of copepods and euphausiids.

Prey	Species Composition (% wt.) May 1984 Sta. C	May 1984 CA[1]	September 1984 Sta. C	September 1984 CA[1]
COPEPODS				
Neccalanus plumchrus	57	outer shelf		
Calanus marshallae	22	mid shelf		
Neocalanus cristatus	13	outer shelf		
Calanoid	8		15	
Centrophages abdominalis	*		47	nearshore
Pseudocalanus minutus	*		15	
Eurytemora herdmani	*		15	nearshore
Epilabidocera longipedata			9	nearshore
Metridia pacifica	*			
Acartia longiremis	*		*	
Oithona similis	*			
Tortanus discaudatus			•	
EUPHAUSIIDS				
Thysanoessa inermis	90	outer shelf		
T. raschii	4			
T. spinifera	6			
No. stomachs examined	5		2	

*<0.5%.

[1]Community Affinity (Cooney 1981).

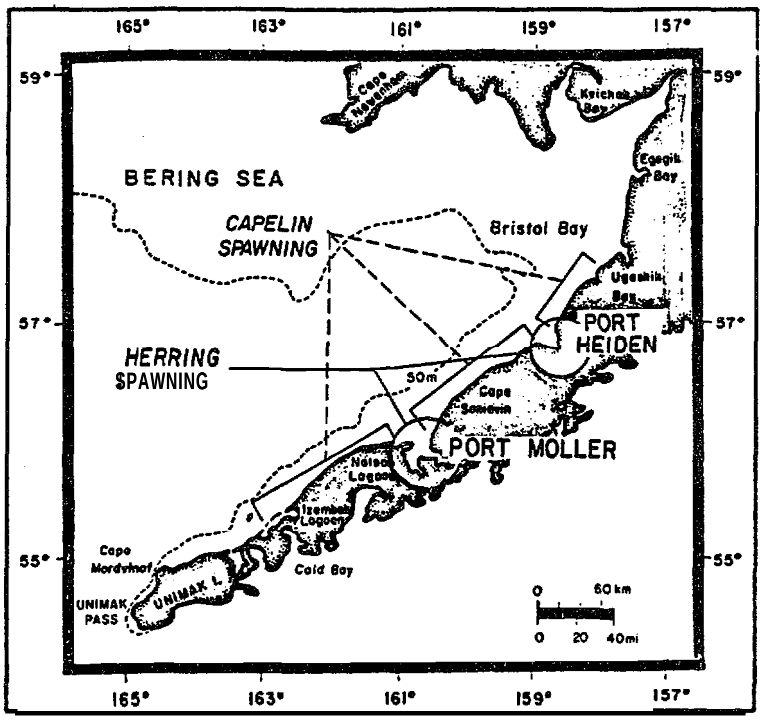


Figure 5.18. Primary spawning areas for forage fishes (Barton et al. 1977).

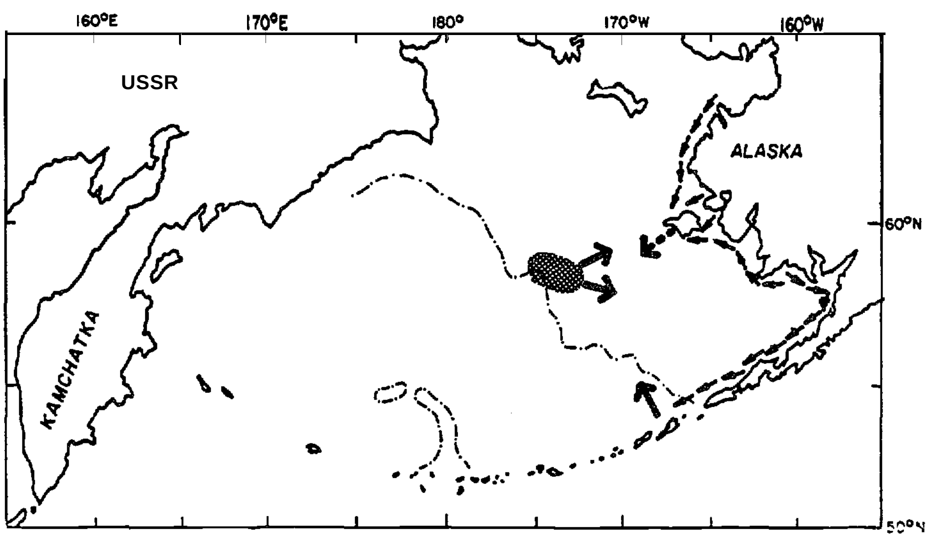


Figure 5.19. Conceptualized migration routes of herring from offshore wintering grounds (stippled area) to coastal areas in spring, and return routes in summer and fall, in the southeastern Bering Sea, Alaska. Redrawn from Wespestad and Barton (1981) and Wespestad and Fried (1983), as modified by ADFG (1985b) to include Unalaska data.

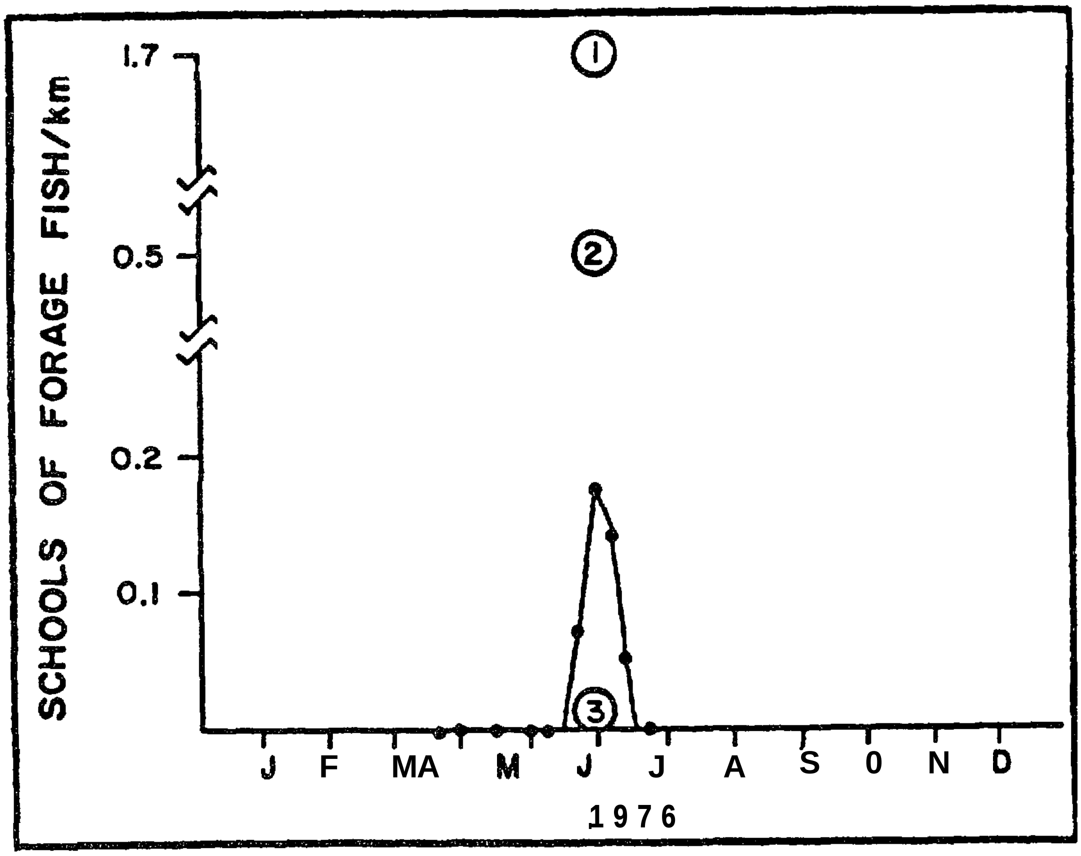


Figure 5.20. Average number of forage fish schools (herring, capelin) observed along the northern shore of the Alaska Peninsula from Unimak Island to Port Heiden (ADFG census areas 1-5) (from Barton et al. 1977). Also shown are maximum numbers at (1) Point Heiden, (2) Izembek area, and (3) Bechevin Bay area.

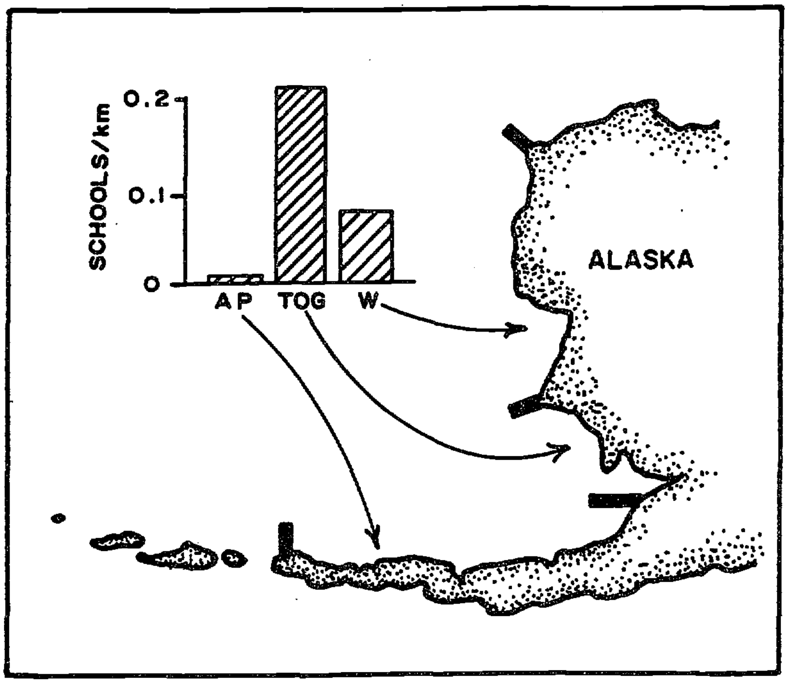


Figure 5.21. Average density of forage fish schools (mostly herring and capelin) observed along the Bering Sea shoreline in spring. Abbreviations; AP (Alaska Peninsula), TOG (Togiak), W (Western Alaska). From Warner and Shafford (1981).

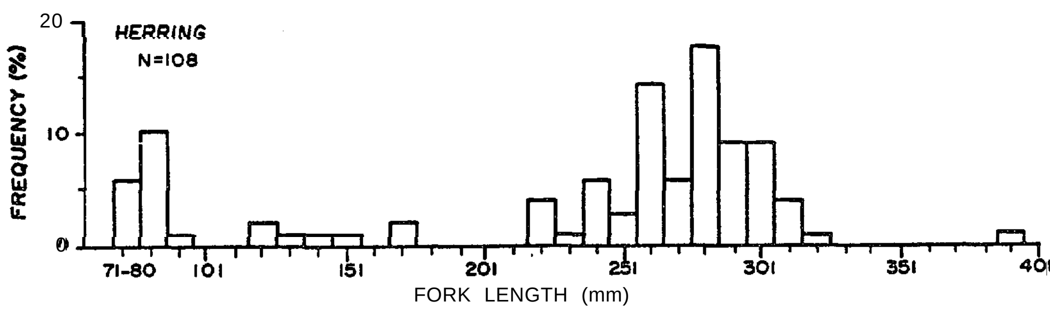


Figure 5.22. Length frequencies of herring collected during this study in the NAN% study area, Alaska.

end of the study area (Transect 1, 20 m) on 20 July 1985, which seems reasonable since herring are known to gather and feed near Unimak Pass and Unalaska Island in summer (summarized by Craig 1986).

The main reason for these low catches was probably that our sampling efforts did not coincide with the June spawning period when herring would be most abundant in nearshore waters. However, the low catches made immediately before this period (May, this study) and afterward (late June, Isakson et al., and July, this study) indicate that the herring did not remain long in the NANZ, and that the migration pattern shown in Figure 5.19 probably occurs, for the most part, farther offshore than our study area extended.

Most of the herring collected by Isakson et al. (1986) were young-of-year (37-55 mm) from the Port Moller area. Our samples consisted of older juveniles and adults, ranging in size from 7 l-400 mm (Fig. 5.22).

Early Soviet studies documented a seasonal pattern of feeding for herring in the eastern Bering Sea. Feeding is greatest after the herring spawn, declines later in summer, and may cease in winter (Svetovidov 1952, Dudnik and Usoltsev 1964, Rumyantsev and Darda 1970). Rumyantsev and Darda (1970) felt that feeding intensity declined in summer because the open waters of the eastern Bering Shelf provided poor summer feeding conditions for herring at this time (Fig. 5.23). Perhaps this is the reason why herring leave the NANZ soon after spawning.

Herring feed on a variety of zooplankton. In the eastern Bering Sea, Rumyantsev and Darda (1970) found that herring consumed mostly euphausiids, fish fry, and copepods. The fish fry eaten were, in order of importance, pollock, sand lance, capelin and smelt. Chaetognaths were also consumed (Dudnik and Usoltsev 1964). In the NANZ, the diets of both large herring (mean size 282 mm) and small herring (mean size 91 mm) were generally similar (Table 5.18). Copepods, crustacean larvae, decapod larvae, and chaetognaths were the main food items.

Capelin (Mallotus villosus). Capelin range throughout the Bering Sea and are extremely abundant in some years (Warner and Shafford 1979). They are generally found offshore in large schools, except during spring when they migrate shoreward to spawn (Macy et al. 1978, Paulke 1985). Schools of spawners are most abundant along the northern shoreline of the Alaska

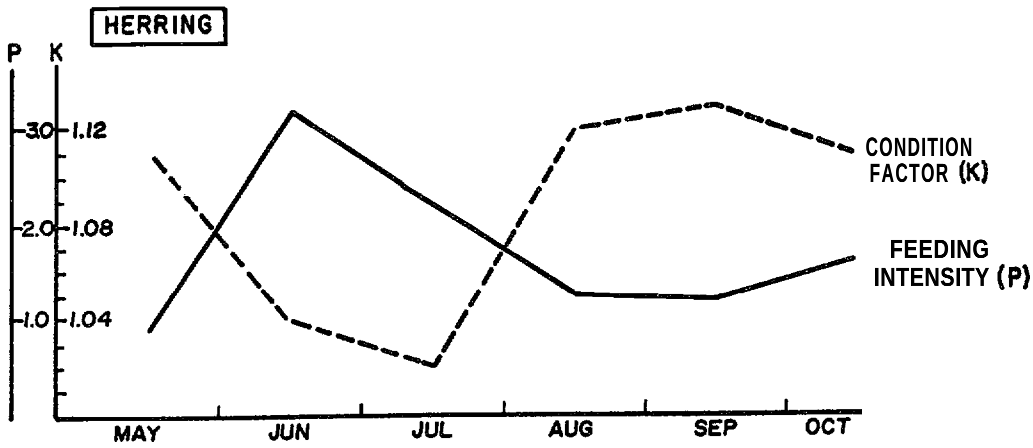


Figure 5.23. Feeding intensity and condition factors of herring caught in the eastern Bering Sea. From Rumyantsev and Darda (1970).

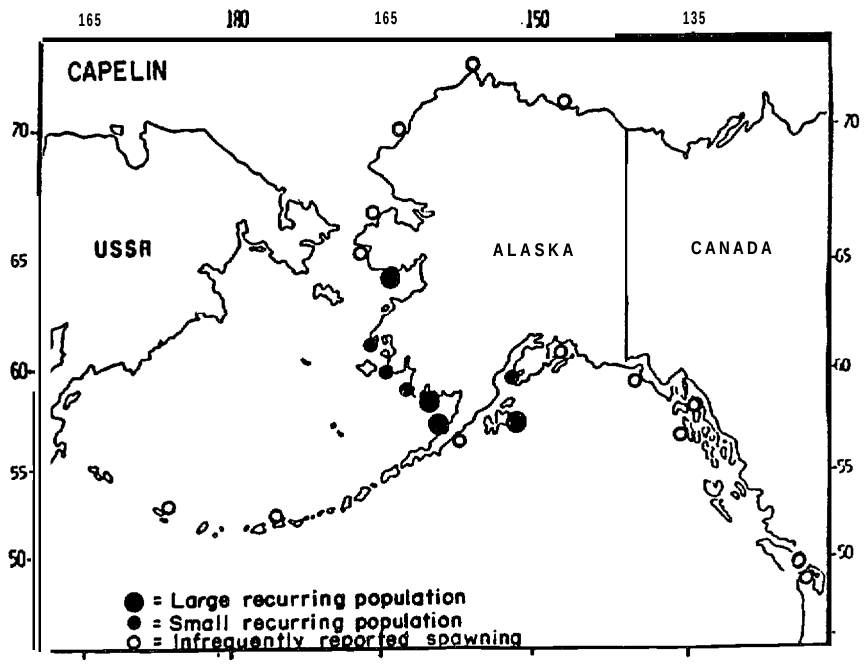


Figure 5.24. Locations of capelin spawning in the Northeast Pacific Ocean. From Paulke (1985).

Table 5.18. **Herring** diets. Note differences in fish sizes.

Food Item	Diet Combosition (%.wt.) July 1985	September 1985
Copepod	26	32
Crustacea larvae	52	1
Decapod larvae	6	36
Amphipod (Total)	(1)	(*)
Hyperiid	1	f
Corophiid	*	
Euphausiid (Total)	(13)	(3)
T. spinifera	2	
T. raschii	1	1
Unidentified	10	2
Chaetognath	f	21
Cypris larvae	1	
Crangonid larvae		5
Mysid (*Acanthomysis*)		1
Jellyfish	1	
Miscellaneous	*	f
Mean contents (mg)	600	45
Fish size (mm) - mean	282	91
- range	240-393	76-172
Sample location	1C	6C
No. fish examined	30	19

*<0.5%.

Table 5.19. Rainbow smelt diets (see Appendix 5.3B for more details).

	Diet Composition (% wt.) by Fish Size, Date and Location: Medium Fish, May 1984	Medium Fish, September 1984	Large Fish, September 1984
Barnacle larvae	13		
Amphipod	41	24	
Mysid	39	68	29
Crangonid shrimp			35
Caridean shrimp			11
Fish		6	24
Other	7	2	1
Ave. contents (mg)	107	48	215
Ave. fish size (mm)	114	111	184
Sample location	6E	6C, 7D	D
No. fish examined	33	36	47

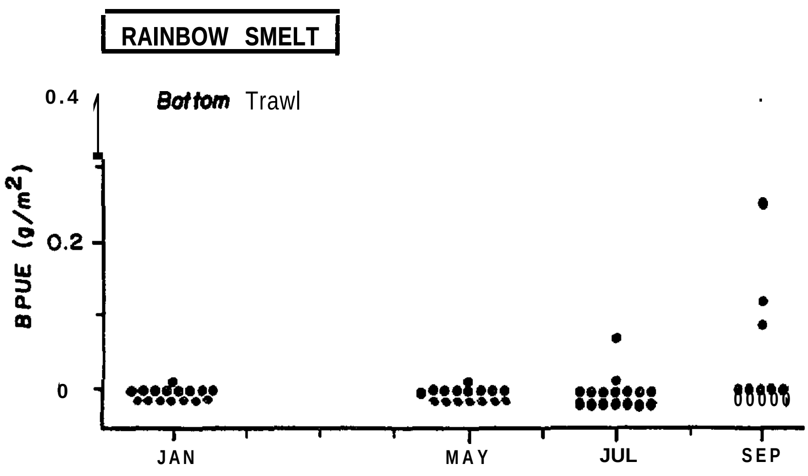
Peninsula from late May to mid-June (Fig. 5.20). Some spawning may occur in the NANZ (Fig. 5.18), but the major spawning areas are located farther east in Bristol Bay (Fig. 5.24).

Although large schools of oapelin (and/or herring) have been sighted in the Port Mollerregionby ADFG (McCullough 1984, Schwartz 1985), few were caught by us or Isakson et al. (1986) in 1984 and 1985. In the two studies combined, less than 10 capelin were caught in 1984 and about 110 in 1985, virtually all of which were taken in the Port Heiden area. Reasons for the discrepancy between our low catches and ADFG estimates of capelin abundance are probably due to the timing of our surveys, which did not coincide with the early June spawning period when these fish would be most abundant nearshore. The absence of capelin in our surveys before this period (May) and afterward (late June for Isakson et al., and July for us) suggests that capelin were present in the NANZ for only a few weeks.

Rainbow Smelt (Osmerus mordax). Rainbow smelt are anadromous fish that spend most of their lives in coastal waters but enter rivers to spawn. Though present in the NANZ, they are more abundant in inner Bristol Bay (Isakson et al. 1986) and have good runs in Nushagak and Togiak rivers (Baxter 4976). It is notknownif rainbow smelt spawn in any streams in the study area.

Rainbow smelt were present in the NANZ during all sampling periods, but catches were highest in September in waters less than 20 m deep (Fig. 5.25). They were also caught directly against the shoreline by beach seines and shoreline gill net sets. Virtually all rainbow smelt (99%) were caught in the eastern portion of the study area (Transects 4-7). They varied in size from 61 to 260 mm (Fig. 5.26).

The feeding habits of rainbow smelt in western Alaska are not well known, but available data indicate that three prey groups--amphipods, mysids and fish--commonly comprise their diets (Warner and Shaf'ford 1981, Haldorsonand Craig 1984, this study). In the NANZ, medium-sized smelt (91-138 mm) consumed mostly amphipods and mysids (Table 5.19). About twice as much feeding occurred in May as in September, as indicated by average weights of stomach contents (Table 5.19). Larger rainbow smelt ate more fish and shrimpand fewer amphipodsthandidthe smaller fish.



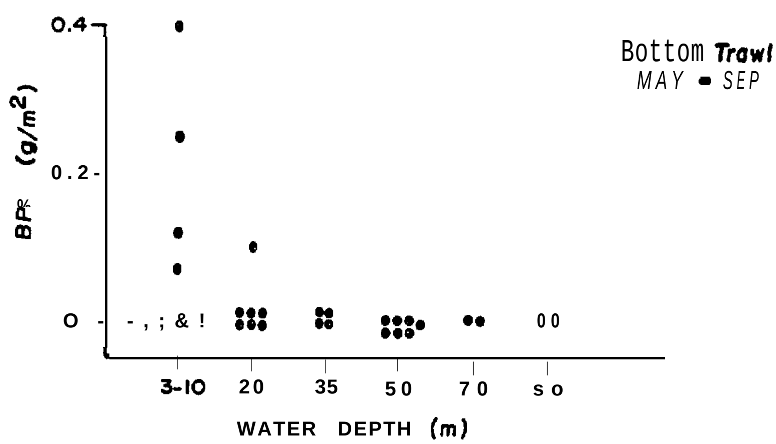


Figure 5.25. Seasonal abundance (top) and abundance at various water depths (bottom) of ranbow smelt caught in the NANZ study area, Alaska. Fish were caught in May and September 1984, and July 1985. Data presented are station averages during various sampling periods (N = 143 bottom trawls TRY1).

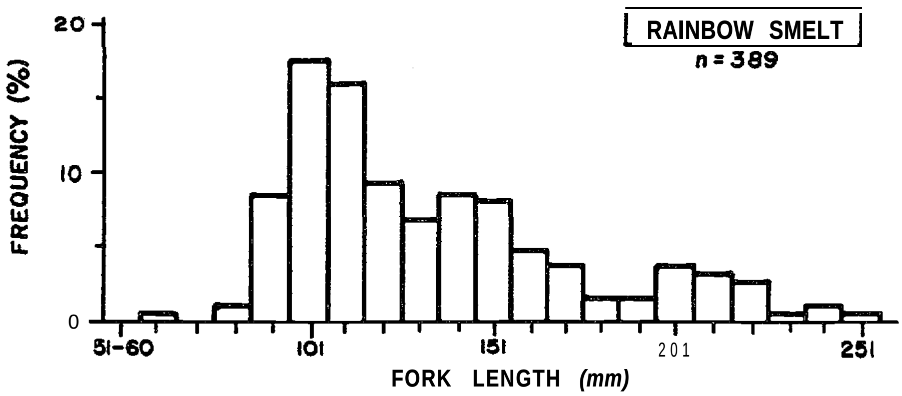


Figure 5.26. Length frequencies of rainbow smelt caught in this study in the NANZ study area, Alaska.

Smith and Paulson (n.d.) note that rainbow smelt in Izembek Lagoon ate amphipods and copepods.

Pollock Young-of-year. These fish are described together with older pollock in Section 5.6.5.3, this report.

5.6.5.2 Salmon

Salmon are the most important anadromous fish in the study area. All five salmon species occur there, but sockeye salmon (*Oncorhynchus nerka*) are by far the most abundant. The annual commercial harvest of salmon in the Bristol Bay region averages about 12 million salmon of which 10 million are sockeye. Approximately 90% of the total salmon run is associated with five river systems (Nushagak, Kvichak-Naknek, Egegik, Ugashik, Togiak) which flow into inner Bristol Bay (Stern et al. 1976).

The total number of adults returning to Bristol Bay streams is impressive--over 25 million fish in recent years (commercial catch plus escapement) (Eggers and Fried 1984). The peak period for these fish passing by the NANZ is from mid June to early July (Fig. 5.27).

Most of these fish migrate in offshore waters beyond the NANZ (Fig. 5.28), but both local and non-local stocks occur in the NANZ. Each year some 1.5 million adult salmon (5-year average) enter streams in the study area to spawn or are caught in nearshore waters by commercial fishermen (Shaul et al. 1983). Many non-local salmon pass through the nearshore zone as well. Dataobtained at the ADFG test fishery off Port Mollerin 1982 indicate that, while most adult salmon migrate more than 90 km offshore, up to 19% of the sockeye and 13% of the chum salmon migrate closer to shore and within the 50-m depth contour (Fig. 2.29). Using these proportions and an estimated run of 22,000,000 sockeye and 2,600,000 chum in 1982, we calculate that about 4,500,000 non-local adult salmon migrated through the NANZ in that year.

Although adult salmon cease feeding as they near their natal rivers, many are still feeding when they pass through the NANZ. Samples collected from the ADFG test fishery off Port Moller showed that only 5% of the sockeye adults had essentially ceased feeding, i.e., had less that 1 g of food in their stomachs (Fig. 5.30). Sockeye stomachs contained an average

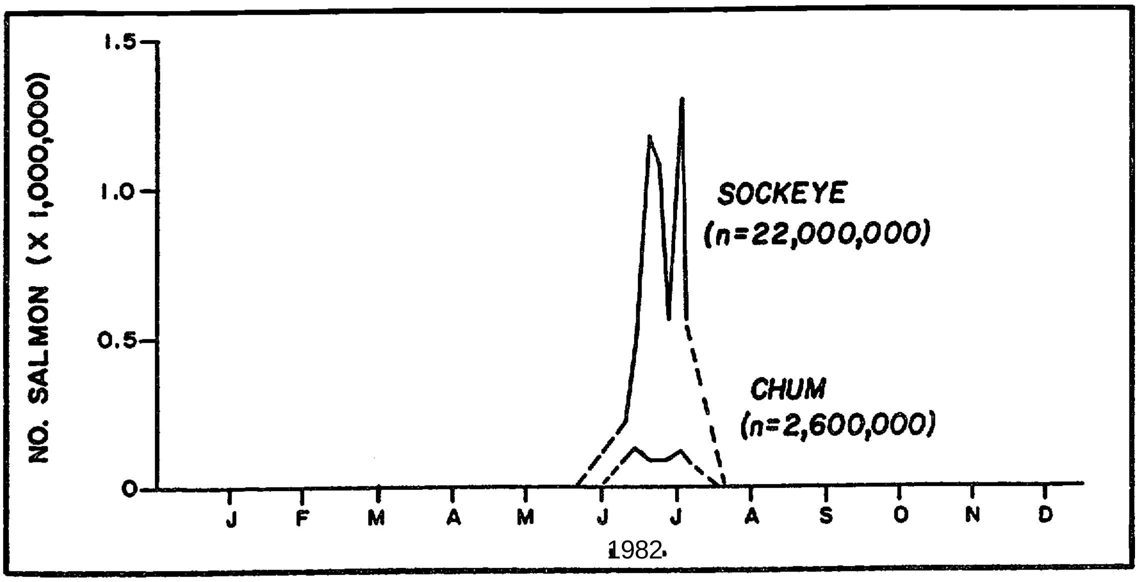


Figure 5.27. Estimated number of adult salmon migrating eastward by Port Moller, derived from catch data from the ADFG test fishery located 45-130 km offshore from Port Moller, 1982. Calculations from Eggers and Fried (1984). Dashed lines indicate possible tail ends for the available data.

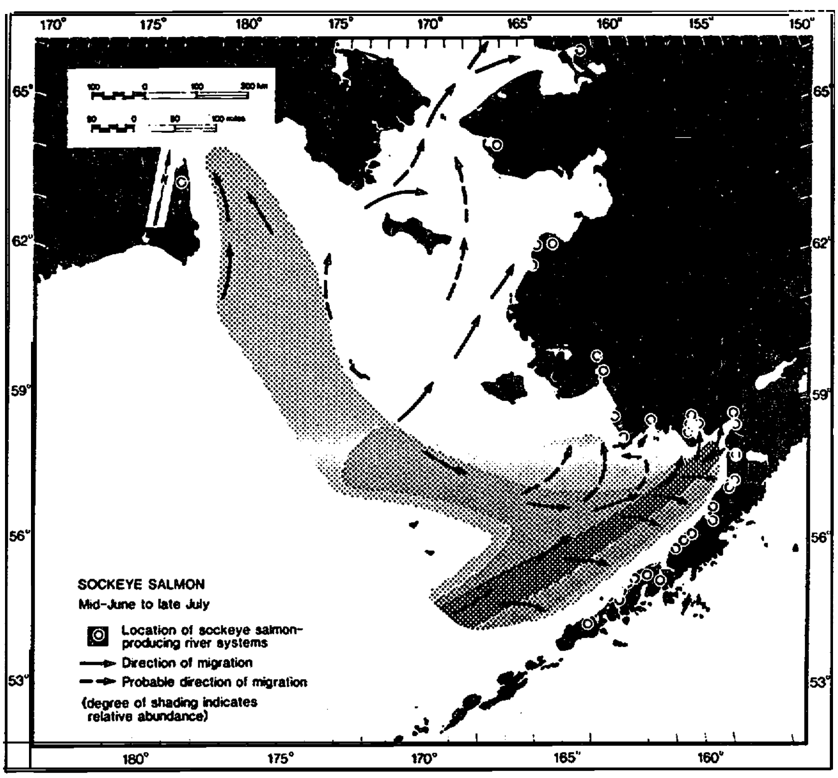


Figure 5.28. Distribution of sockeye salmon during spawning migration, From Straty (1981).

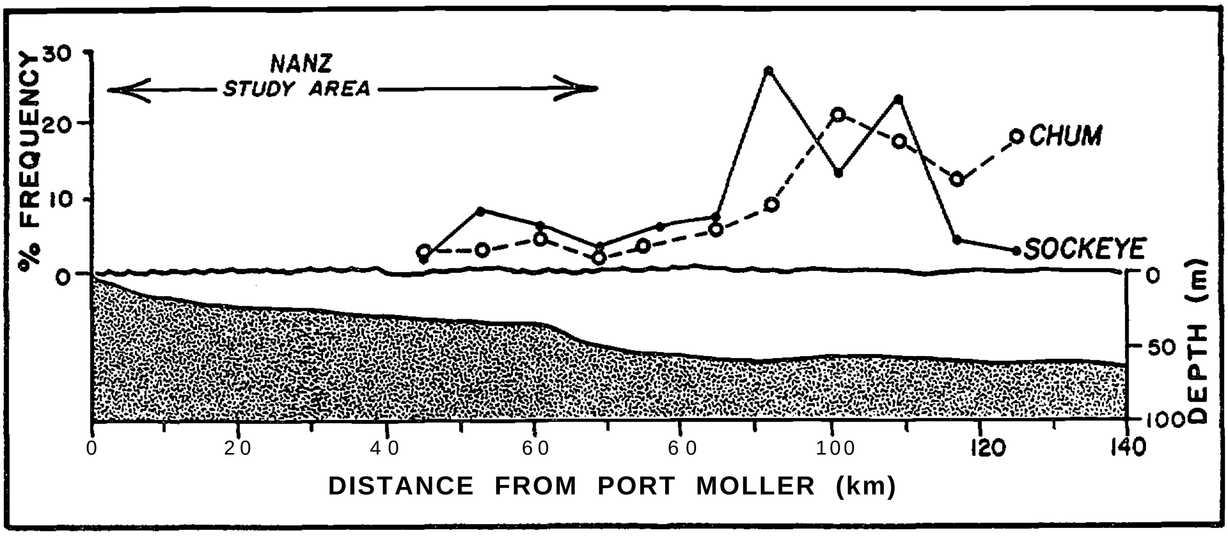


Figure 5.29. Pathway (distance offshore) for some adult salmon migrating eastward past Port Holler, 1982. Calculated from Eggers and Fried (1984).

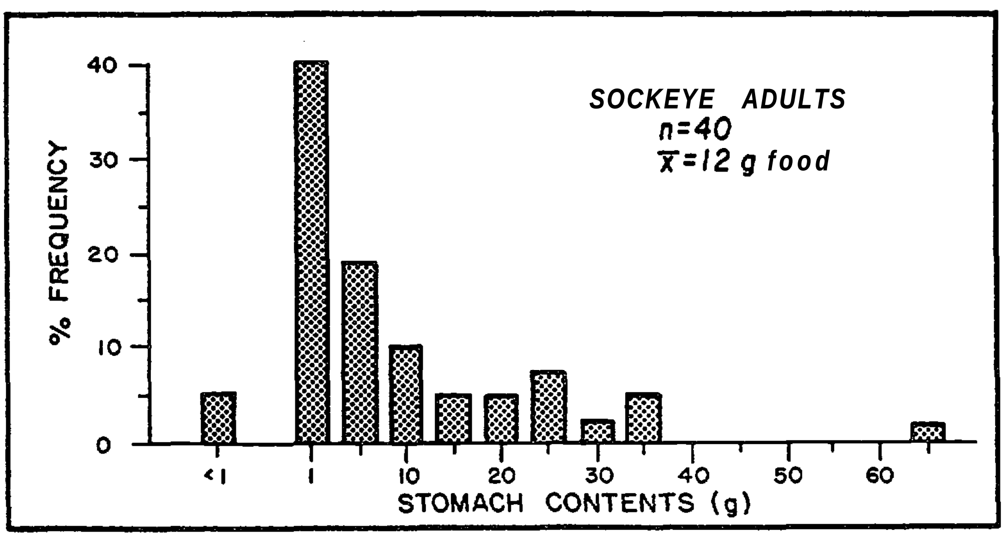


Figure 5.30. Stomach fullness of adult sockeye caught in the ADFG test fishery off Port Moller, June 1985.

of 11.9 g of food and chum stomachs 6.5 g (Table 5.20). Euphausiids (Thysanoessa) comprised virtually all of the sockeye's diet; this agrees with Nishiyama's (1974) finding that sockeye caught in the central basin region of the Bering Sea consumed a variety of pelagic species (squid, fish larvae, amphipods, euphausiids), but that those on the continental shelf ate euphausiids almost exclusively.

Using these figures, and assuming that the average amount of food found in their stomachs is the amount consumed daily, we estimate that adult sockeye and chum together consume about 280,000 kg of euphausiids daily as they migrate through the NANZ. The average migration speed of sockeye during this time is 60 cm/s or 30 nautical miles/day (Hartt 1966). At this rate, it would take about seven days for a salmon to traverse the NANZ. Thus, the total consumption of euphausiids by adult salmon would be about 2 million kg, extended over the one-month period of their run through this area.

The escapement of juvenile salmon into Bristol Bay averages about 580 million, all species combined. These smolts migrate westward across southern Bristol Bay in a band about 50 km wide, after which they apparently move seaward in the vicinity of Port Moller and thus are generally dispersed seaward of our study area (Straty 1981). They are most abundant from late May through September (Straty and Jaenicke 1980, Isakson et al. 1986). Juveniles generally take six months or longer to reach the north Pacific where they remain for 1-4 years before returning to spawn.

Juvenile salmon in Bristol Hay and the eastern Bering Sea feed on zooplankt on, epibenthie crustaceans, and small fish during their initial months at sea. Depending on season and location, the most important foods of juvenile sockeye are copepods (Carlson 1963), sand lance (Straty 1974), or larval fish and euphausiids (Dell 1963). Most feeding (and initial growth at sea) occurs only after the newly smolted sockeye migrate out of inner Bristol Bay to the Port Moller area and beyond (outer Bristol Bay), where densities of prey are higher and sockeye stomachs are fuller (Fig. 2.31). Food type, size, and abundance probably determine how long juvenile salmon reside in a given geographical region during their seaward migration (Straty and Jaenicke 1980).

Table 5.20. Adult sockeye and chum salmon diets. Samples were provided by the Alaska Department of Fish and Game from their test fishery off Port Moller.

Food Item	Diet Composition (% wt.) by Species Adult Salmon (June 1985) Sockeye	Chum
Euphausiid (total)	(98)	
Thysanoessa	49	
Miscellaneous	49	
Fish	1	*
Crustacea	*	
Cypris larvae	*	
Decapod larvae	*	*
Amphipod		*
Copepod		*
Ave. contents (g)	11.9	6.5
Fish size (mm) - mean	580[1]	582[1]
-range	527-621[1]	560-601[1]
Sample site	6Y	6Y
No. stomachs examined	40	7

*<0.5%.
[1] Mid-eye to tail fork.

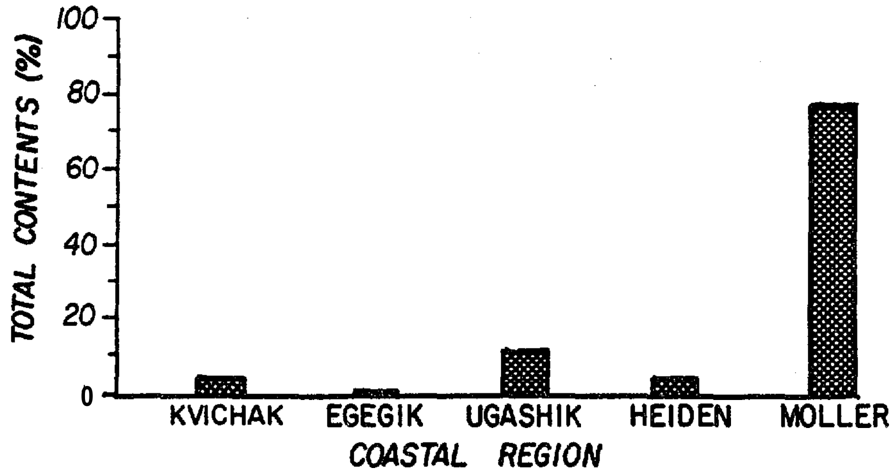


Figure 5.31. Proportions of foods eaten by sockeye salmon smolts at five Bristol Bay regions, proceeding from the inner bay (Kvichak) to outer bay **(Moller).** From **Carlson** (1963).

In the NANZ, samples of juvenile salmon were collected in Izembek Lagoon, and over a wider coastal area (Izembek Lagoon to Port Heiden). The main foods eaten *were* as follows (Table **5.21)**:

sockeye juveniles - euphausiids, sand lance
chum juveniles - decapod larvae, amphipods, sand lance, insects, **mysids,** and plant material
coho juveniles - sand lance
pink juveniles - amphipods, copepods, decapod larvae

5.6.5.3 Demersal **Fishes**

As previously described (Section 5.6.1, this report), the community of demersal fishes of the **NANZ** is similar to that which characterizes the Bering Sea middle shelf. Yellowfin and rock sole together accounted for most of the catch, followed by pollock and Pacific cod:

TOTAL BOTTOM TRAWL CATCH		
Fishes	Number (%)	Biomass (%)
Yellowfin and rock sole	56	79
Pollock and Pacific cod	18	4
Other	26	17

Gear: TRY1

Seasonal trends in the total biomass of demersal fish catches reflected the biomass fluctuations of yellowfin sole (Fig. 5.32). Total numbers of fish, however, were more evenly divided among the abundant species. Summary tables of all species caught in bottom trawls are presented in Appendix **5.1.**

Note that CPUE and BPUE data presented herein for the Marinovitch bottom trawl **(=TRY1)** probably underestimate actual fish numbers and biomasses, as discussed in Section **5.6.3.1.**

Table 5.21. Juvenile salmon diets (see Appendix 5.3 C for more details).

	Diet Composition (% wet.) by Species, Date and Location					
	Sockeye	Chum			Coho[1]	Pink
	1984	7/84	7/85	9/84[1]	1984	7/84
Euphausiid	42				1	
Fish	36		13	95	93	
Mysid	7	18		3		
Barnacle larvae	6					1
Insects	5		31	1	1	
Amphipod		27	20		5	39
Copepod		3	2			28
Decapod larvae		45	4			24
Cumacea		6	4			4
Polychaete						4
Plant material			25			
Other	4	1	1	1		
Ave. contents (mg)	429	116	29	864	1410	38
Ave. fish size (mm)	107	2F	2F	134	129	75
Sample site	misc.[1]	30	30	PH	misc.[1]	2F
No. stomachs	30			20	26	7

[1]Samples from combined locations and dates (Izembek Lagoon to Port Heiden, June-September 1984) provided by J. Isakson (Dames and Moore).

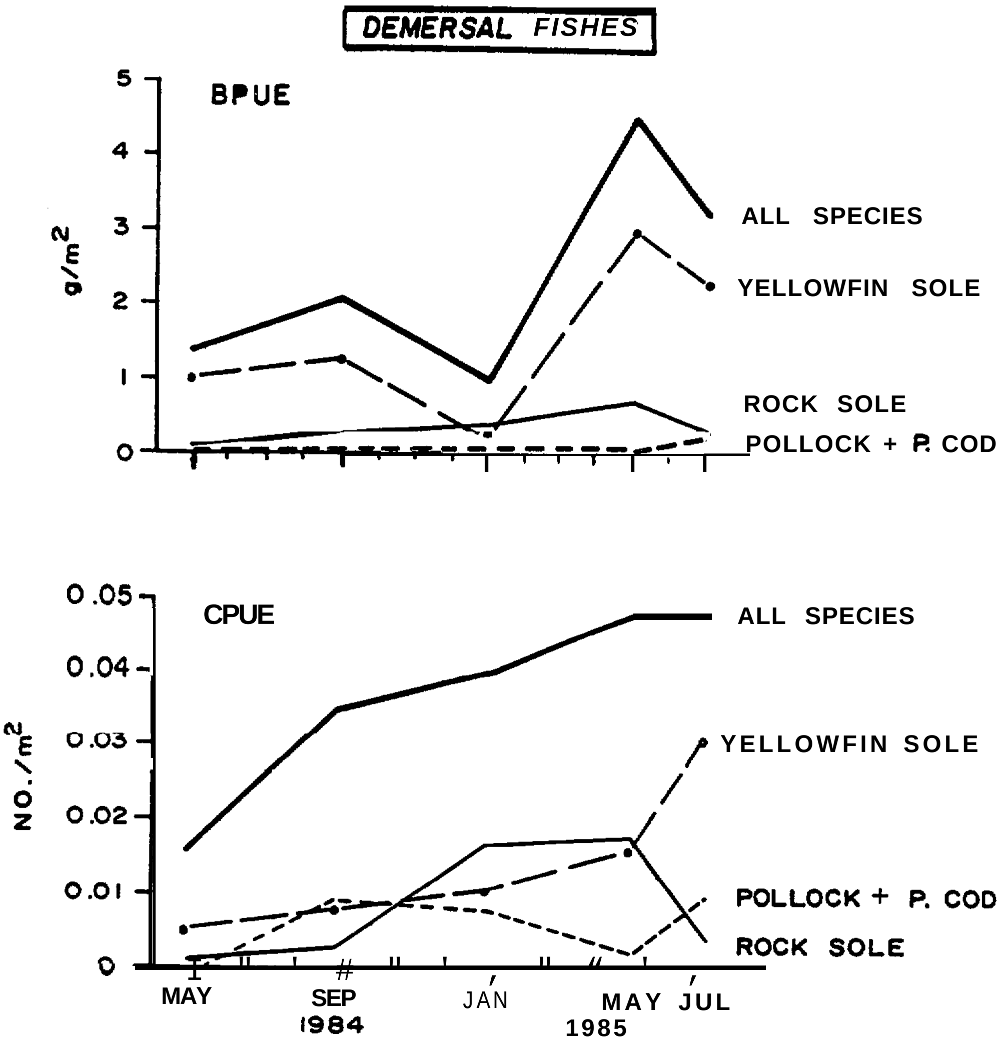


Figure 5.32, Seasonal BPUE and CPUE for demersal fishes caught by bottom trawl (TRY1) during this study in the NANZ study area, Alaska. Note that BPUE and CPUE are probably underestimated due to gear-related bias (see Section 5.6.3.1).

Yellowfin Sole (Limanda aspera). This species is by far the dominant flatfish in the Bering middle shelf (Table 5.4) and in the shallow waters of the NANZ as well (Table 5.6). Yellowfin sole were abundant in demersal habitats throughout the study area (Table 5.7) and accounted for 36% of the catch and 66% of the biomass of all fish caught by small bottom trawl.

The seasonal distribution and abundance of yellowfin sole in the study area need to be viewed in the context of their overall movement patterns in the eastern Bering Sea (summarized by Bakkala 1981 and ADFG 1985a). Adult yellowfin overwinter in large schools along the outer shelf, with largest concentrations at depths of 100 to 200 m. One major overwintering area is located north of Unimak Island. In spring (May), these fish migrate into shallower water on the middle and inner shelves to feed and spawn (Fig. 5.33). By summer, the Unimak winter group is found in the Bristol Bay area between the 40-to 100-m depth contours (Fig. 5.34). As winter approaches, the fish move back into deeper water, although in warm years some may remain on the middle shelf throughout the winter. Young yellowfin remain in relatively shallow nearshore waters throughout their first few years of life.

Data obtained in the NANZ support the above patterns of movement. Although yellowfin catches were highly variable, ranging from 0-20 g/m2 in individual trawls, BPUE estimates were low in winter and high in summer (Fig. 5.35). In contrast, CPUE results showed a steady increase throughout the study. An interpretation of these results is aided by viewing the length frequencies of the fish present during each sampling period (Fig. 5.36). Beginning in May 1984, both large and small yellowfin were present in the NANZ. More small fish entered the area by September (Fig. 5.36), ultimately accounting for the CPUE increase and BPUE decrease in January. The following spring (May 1985), many large yellowfin moved into the study area as shown by their length frequencies and by increases in both CPUE and BPUE. These fish were presumably on their way from the Unimak wintering area to Bristol Bay to spawn. By mid-summer (July), many of the larger fish had left the area and were replaced by smaller fish as occurred the previous year.

The winter (January) data indicate two important points: (1) some yellowfin inhabit the shallow waters of the study area year-round, and (2)

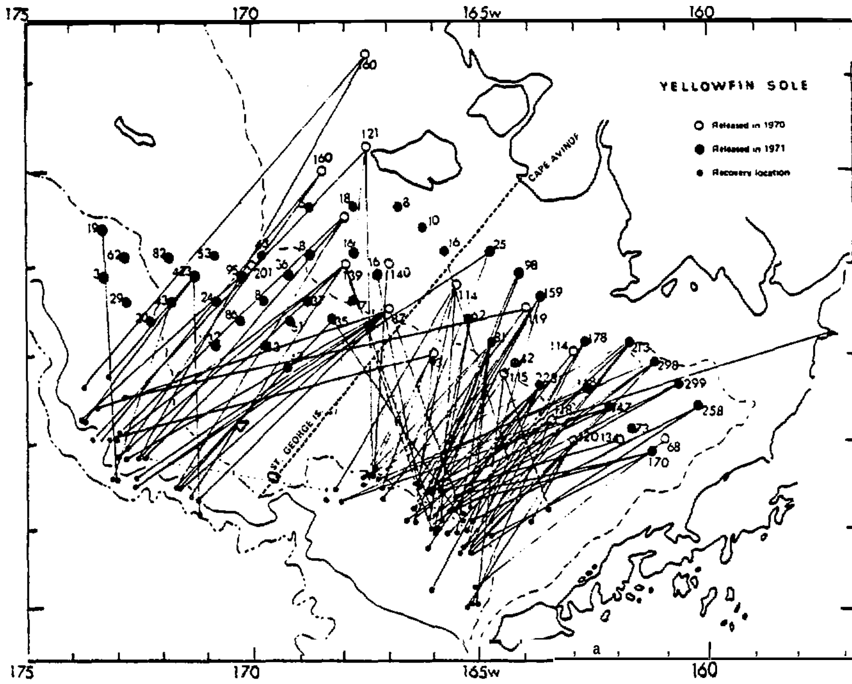


Figure 5.33. Tag and recovery sites for yellowfin sole in the south-eastern Bering Sea, Alaska. From Wakabayashi et al. (1977).

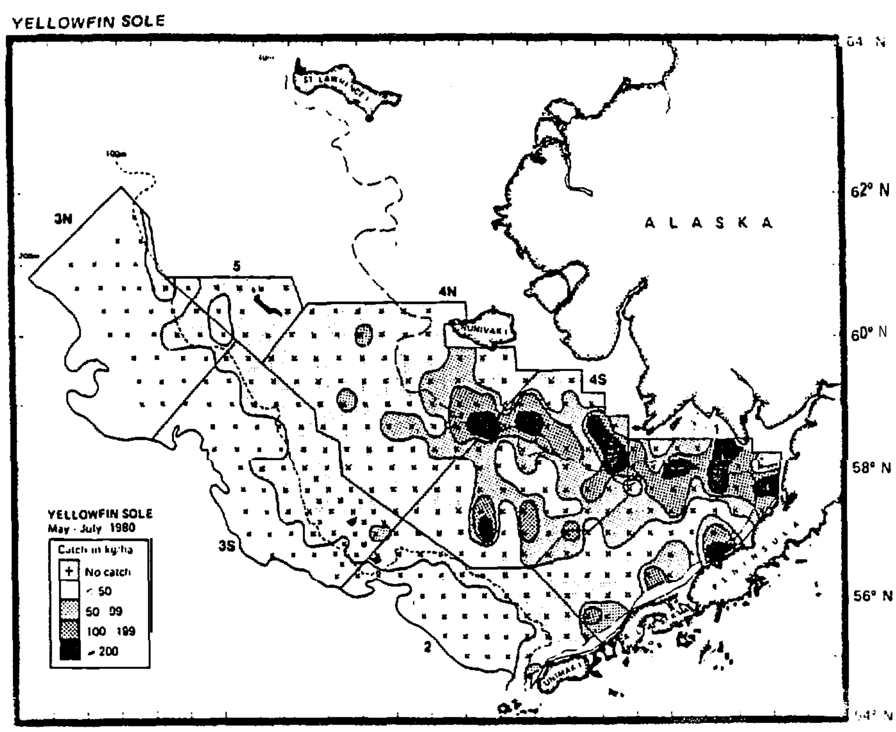


Figure 5.34. Catch distribution of yellowfin sole in the southeastern Bering Sea, Alaska, during the 1980 NMFS trawl survey. From Umeda and Bakkala (1983).

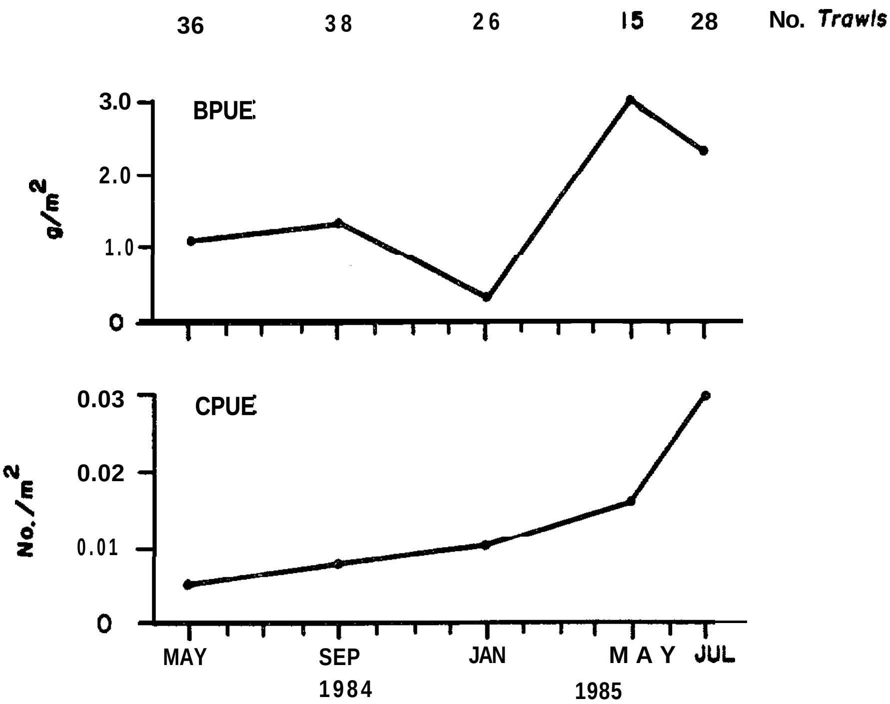


Figure 5.35. Seasonal BPUE and CPUE of yellowfin sole caught in bottom trawls (TRY1) during this study in the NANZ study area, Alaska. Note gear-related bias in Section 5.6.3.1.

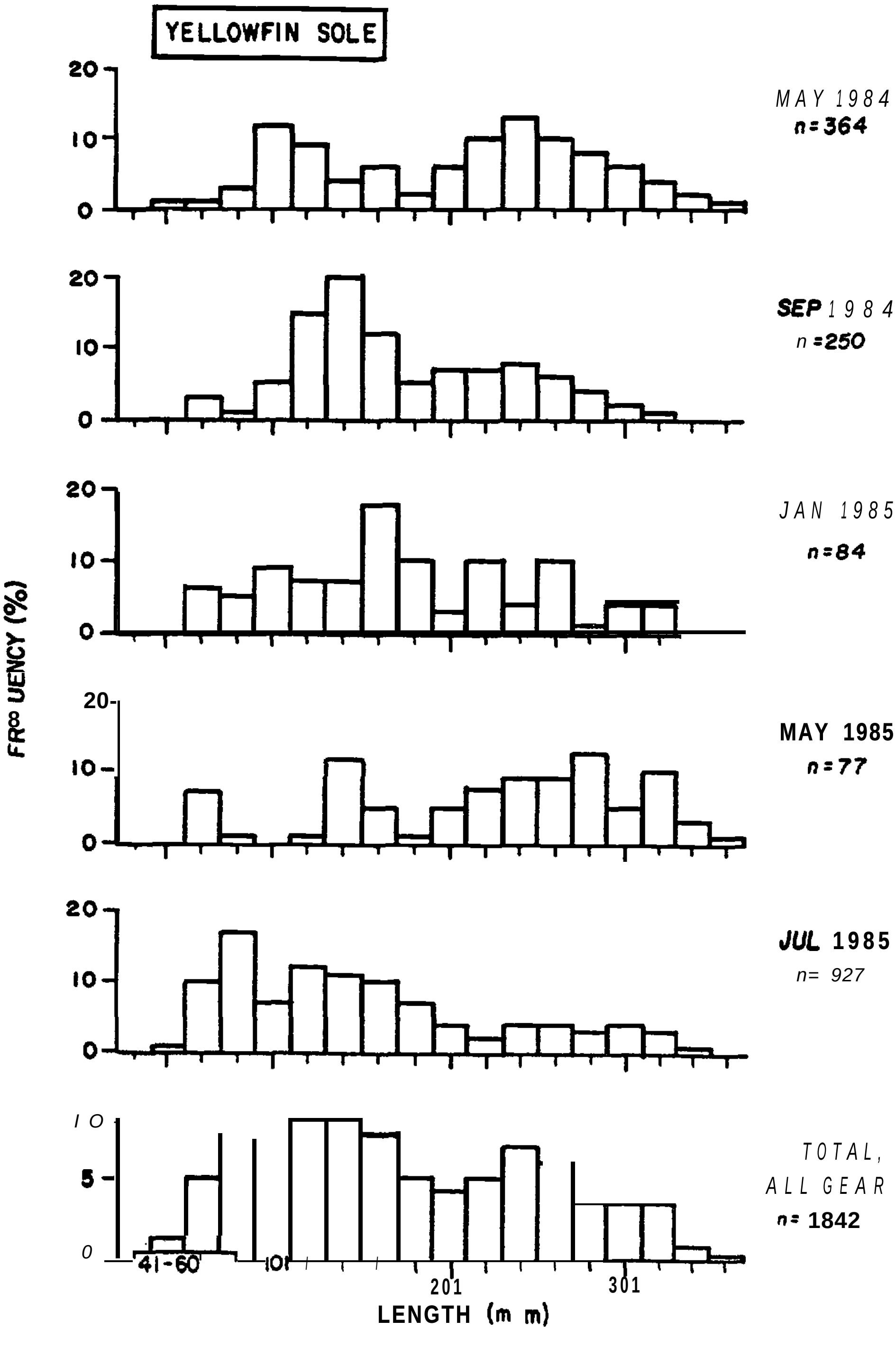


Figure 5.36. Length frequencies of yellowfin sole caught in bottom trawls (TRY1) in the NANZ study area, Alaska. The bottom graph shows all gear and dates combined.

the relatively high CPUE but low BPUE in January indicate that many juvenile yellowfin sole used the NANZ to overwinter.

The total sample of yellowfin ranged from 35-373 mm in length (Fig. 5.36). Isakson et al. (1986) caught proportionally more small yellowfin along the north side of the Alaska Peninsula, perhaps because they did not sample in May when many large yellowfin moved through the nearshore zone.

Although small yellowfin (less than 200 mm) were abundant in nearshore waters, it is not known if they are also abundant farther offshore, because most trawl surveys in offshore waters (e.g., the annual NMFS surveys) use large trawls with mesh sizes that may be too large to retain the smaller fish..

Within the NANZ, yellowfin were most abundant in water less than 50 m deep, with highest catches in 20 m or less (Fig. 5.37). A few yellowfin were also caught in even *shallower* water by beach seine and gill nets set adjacent to the shoreline. By comparison, rock sole were more abundant in slightly deeper water (Fig. 5.38).

Yellowfin tended to be most abundant in the Port Moller area (Fig. 5.39, Transects 6 and 7), although high catches were occasionally made throughout the study area during the various sampling periods. NMFS trawl data also show a local abundance near Port Moller (Fig. 5.34), but this concentration was not present in allyearsthattheir surveyshave been conducted.

The food habits of yellowfin sole in the eastern Bering Sea have been summarized by several authors (e.g., Pereyra et al. 1976, Bakkala 1981), based in large part on earlier studies by Skalkin (1964). Yellowfin sole are benthic feeders, consuming a variety of infauna and epibenthos. The kinds and amounts of prey consumed vary with season, area and size of fish. They feed relatively little in winter; in summer their diets include polychaetes, amphipods, bivalves, euphausiids, echiuroid worms, and echinoderms. Near Port Moller, Haflinger and McRoy (1983) found that yellowfin sole consumed small surf clams, polychaetes, amphipods, and sand dollars.

Diets of yellowfin sole in the NANZ were similar to the above (Table 5.22). The amount consumed was greatest in spring, intermediate in summer, and least in winter (Fig. 5.40). Small yellowfin sole ate copepods, amphipods, polychaetes, and fish; large yellowfin ate a varied

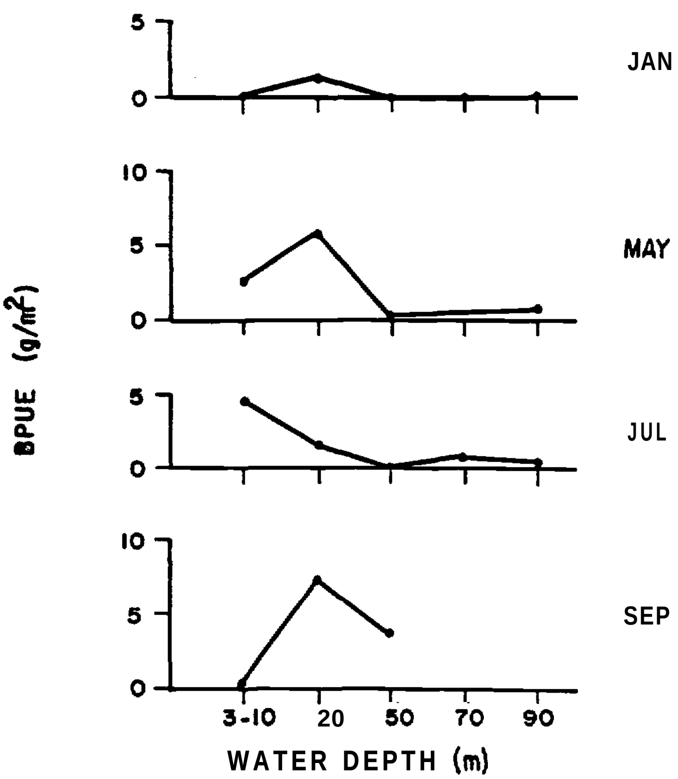


Figure 5.37. Depth distribution of yellowfin sole caught by month in the NANZ study area, Alaska. Data presented are station averages for catches in TRY1.

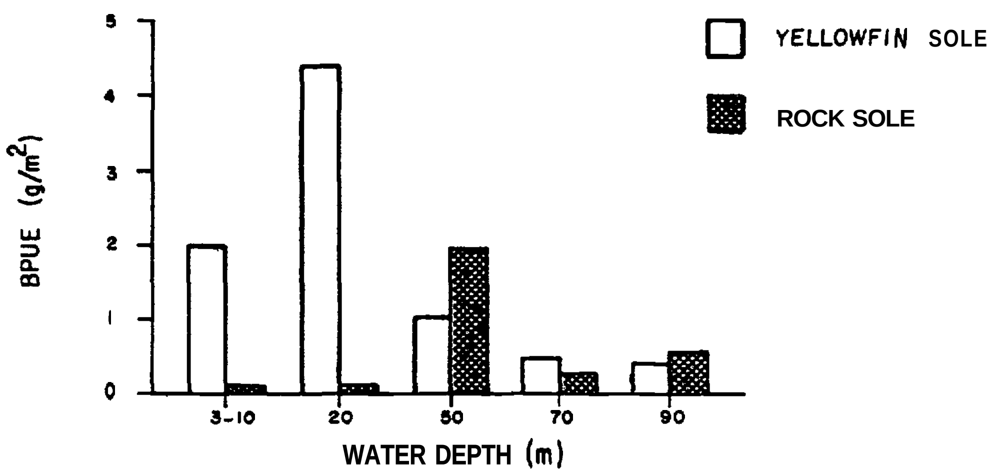


Figure 5.38. Depth distribution of yellowfin and rock sole caught by TRY1 in the NANZ study area, Alaska, all sampling dates combined.

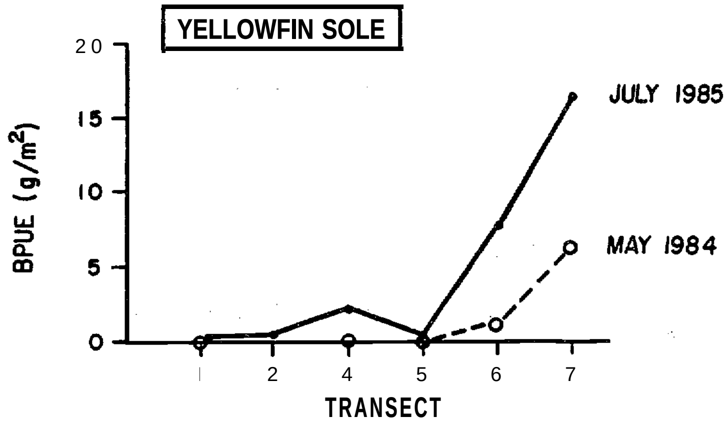


Figure 5.39. Relative abundance of yellowfin sole from east to west along the 3-10 m depth zone in the NANZ study area. Gear: TRY1; note gear-related bias in Section 5.6.3.1.

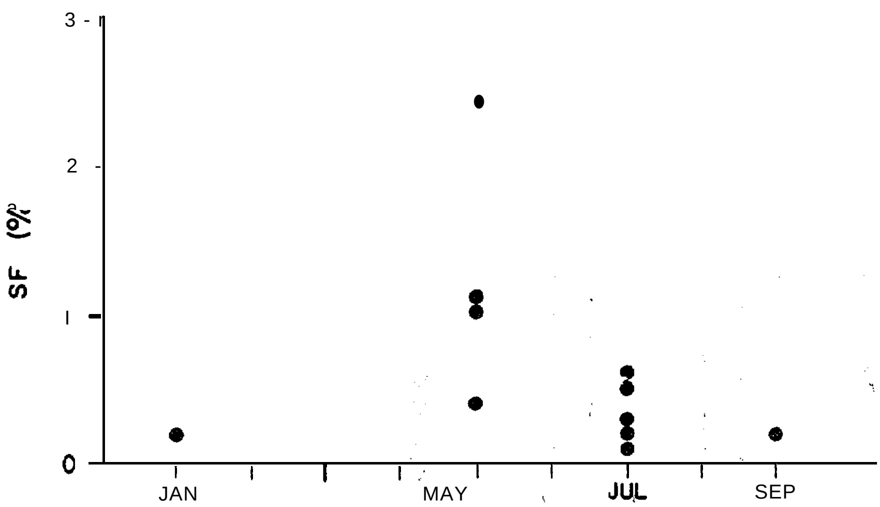


Figure 5.40. Stomach fullness index (SFI) for yellowfin sole by month in the NANZ study area. For each group of fish listed in Table 5.22, SFI = 100 x average weight of stomach contents divided by the average weight of fish in the group.

Table 5.22. Yellowfin sole diets (see Appendix 5.3 D for more details).

Food Item	Small Fish: May 1984	Small Fish: July 1985a	Small Fish: July 1985b	Large Fish: Jan 1985	Large Fish: May 1984a	Large Fish: May 1984b	Large Fish: May 1985	Large Fish: July 1985a	Large Fish: July 1985b	Large Fish: July	Large Fish: Sept 1984
	Diet Composition (% wt.) by Fish Size, Date and Location										
Copepod		60	2								
Amphipod	81	10	17	4	5	8	1	2			11
Polychaete	3	17	5	35		46	41	47	a	3:	
Crangonid			1	27	4	1	13	8	33	1	19
Bivalve	8			6	76	1	18	15	17	22	26
Echinoderm	5			1	4	13	11			10	
Pagurid		6				17				5	
Echiuroid worm				15							
Decapod misc.	1	2			2			1		2	32
Fish			73	3		7	2	28			3
Euphausiid				2	9					4	
Plant							2		39		5
Isopod							8				
Gastropod										11	
Jellyfish										9	
Other	1	5	2	7		7	4		2		4
Ave. contents (mg)	224	11	67	209	2939	1795	695	413	312	576	260
Ave. fish size (mm)	115	76	104	212	222	243	251	183	280	290	216
Sample sites	2B,C	D,E	D	A,C	2B,C	6A,C	misc.	1D,E	6D	X,Y	6D
No. stomachs	18	32	30	25	17	46	33	24	38	28	23

diet of polychaetes, crangonid shrimp, and bivalves, with lesser amounts of amphipods, sand dollars, fish (sand lance), and, unexpectedly, plant material.

The available data provide some dietary comparisons between years and locations (Table 5.23). Yellowfin sole diets were generally similar in May of both 1984 and 1985, but location-specific differences were noted. The foods eaten in the eastern and western portions of the study area (Transect 6 versus Transects 1 and 2) differed in May 1984 and July 1985, but no consistent pattern was apparent. Similarly, yellowfin diets in nearshore sites (water depths 3-10 m) differed from those in offshore sites (50-70 m), but the only "new" foods encountered offshore were gastropods (11% of diet) and jellyfish (9%). The remaining 80% of their offshore diet consisted of food groups eaten in nearshore waters at different locations or seasons. The diet of yellowfin sole thus appears to be flexible.

Rock Sole (Lepidopsetta bilineata). Though much less numerous than yellowfin sole, the rock sole is a common and widely distributed species in the eastern Bering Sea (Table 5.4, Fig. 5.41). Seasonal movements are notwellknown but are thought to be similar to those of other flatfish such as yellowfin sole.

Rock sole were moderately abundant in the NANZ, accounting for 13% of the biomass and 20% of the total catch in TRY1 bottom trawls. The average catch was 0.3 g/m2 and 0.007 fish/m^2. The seasonal abundance was highly variable, with minimum and maximum catches occurring in the spring of the two years of study (Fig. 5.42).

The CPUE, BPUE, and length frequencies of rock sole (Figs. 5.42 and 5.43) suggest the following movements of fish in the study area. The low catches of rock sole in May 1984 consisted primarily of small fish less than 80 mm. By late summer (September), large rock sole had moved into the area and the small fish had departed, perhaps moving into shallower water as suggested by the catches of small rock sole (91-160 mm) in nearby embayments by Isaksonetal. (1986). In winter (January), the high CPUE but unchanged BPUE indicates that many small rock sole wintered in the NANZ, especially juveniles 41-60 mm in length but including larger fish as well. High catches in May 1985 consisted primarily of small fish (as

Table 5.23. Yellowfin sole diets: oomparisons between years and locations.

	Diet Composition (%.wt.) by Year and Location							
			Locations					
			May 1984		July 1985		July 1985	
	Years						Near-shore	Off-shore
	1984	1985	East	West	East	West		
Polychaete	3	41		46	47	3:	27	35
Crangonid	38	18 13	4	1	8		20	
Bivalve			76	1	15	17	16	2:
Amphipod	6		5	8	2	2	2	1
Echinoderm	9	1:	4	13				10
Pagurid	8			17				5
Decapoa misc.	1		2		1			2
Fish	4	2		7	28		14	
Euphausiid	4		9					4
Plant		2				39	20	
Isopoa		8						
Gastropod								11
Jellyfish								9
Other	4	4		7		2	1	
Ave. contents (mg)	2367	695	2939	1795	413	312	363	576
Ave. fish size (mm)	233	251	222	243	183	280	232	290
Sample sites	misc.	misc.	2B,C	6A,C	lD,E	6D	D,E	X,Y
No. stomachs	63	33	17	46	24	38	62	28

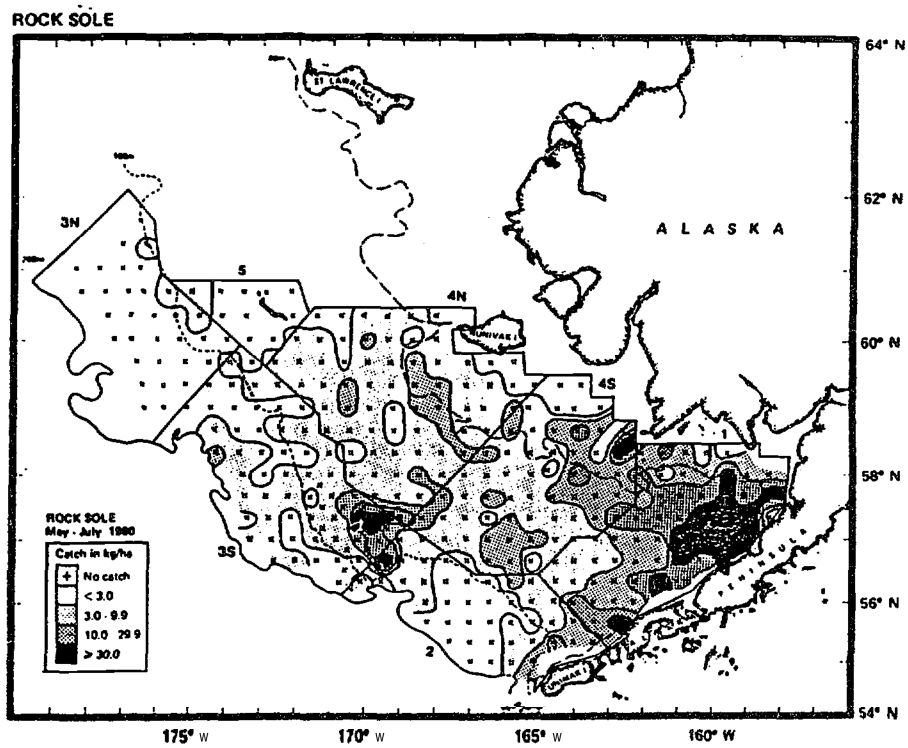


Figure 5.41. Catch distribution of rock sole during the 1980 NMFS survey, Bering Sea, Alaska. From Umeda and Bakkala (1983).

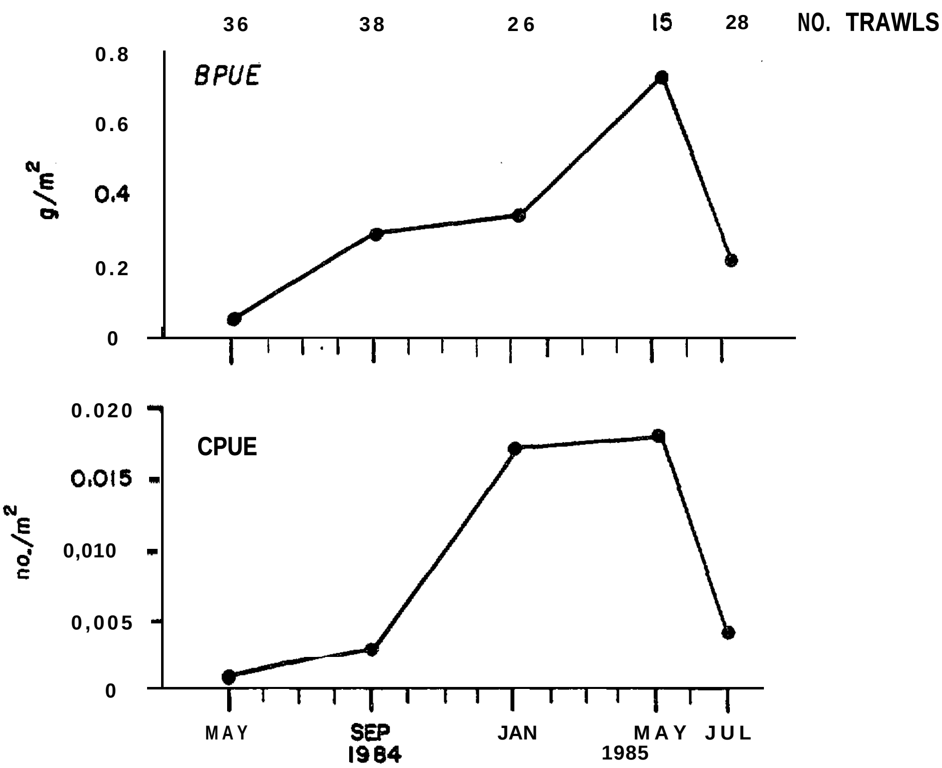


Figure 5.42. Seasonal BPUE and CPUE of rock sole caught in bottom trawls in the NANZ study area, Alaska. (Gear: TRY1). Note gear-related bias in Section 5.6.3.1.

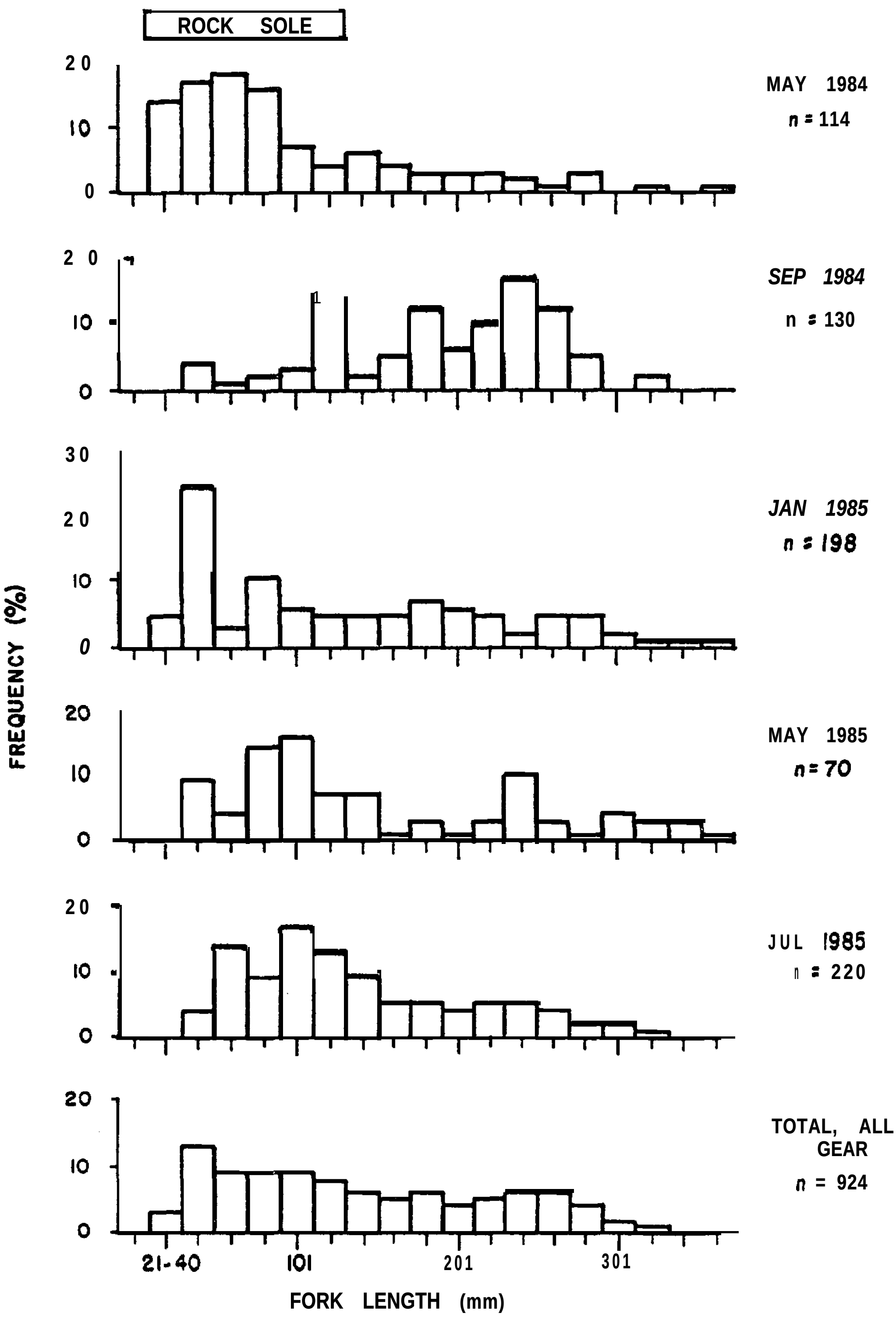


Figure 5.43. Length frequencies of rock sole caught by TRY1 bottom trawl on various dates in the NANZ study area, Alaska. Bottom graph shows all gear and dates combined.

occurred the previous spring), although the high BPUE indicates many large fish as well. A precipitous exodus of rock sole from the area occurred prior to mid-summer.

While the above information is sketchy, the scenario indicates the same two points previously noted for yellowfin sole: (1) rock sole inhabit the shallow waters of the NANZ year-round, and (2) the area is particularly important to juveniles.

Rock sole were distributed throughout the NANZ but were most abundant in the deeper portions of the study area. Highest BPUE estimates occurred at the 50-m Station in contrast to yellowfin sole which were more abundant in shallower water (Fig. 5.38).

The benthic food habits of rock sole In the NANZ are generally similar to diets reported for this species in the offshore waters of the Bering Sea shelf. There, large rock sole eat polychaetes, fish, amphipods, mollusks, and echinoderms (Skalkin 1964, Shubnikov and Lisovenko 1964, Mito 1974). In the NANZ, polychaetes and amphipods were important food items for all size classes of rock sole in this study (Table 524). Some size-related shifts in diet were apparent; small rock sole ate copepods, medium-sized sole ate mysids and euphausiids, and large sole ate fish (often sand lance), benthic worms, and echinoderms (sea urchins, sand dollars, brittle stars). Cimberg et al. (1984) reported generally similar diets for rock sole In the NANZ as well. Stomach fullness data indicate that rock sole fed more in spring and summer than in winter (Fig. 5.44), as has been reported in earlier studies (Shubnikov and Lisovenko 1964).

Our data show'considerable variability among rock sole diets at different locations in the NANZ. In shallow habitats (about 10 m deep), rock sole ate proportionally more fish, amphipods, and bivalves and fewer polychaetes than in deeper water (Table 5.25). Diets in eastern and western portions of the study area (Transects 6 and 7 versus Transect 2) also differed in the proportions and amounts of foods eaten.

Walleye Pollock (Theragra chalcogramma). The walleye pollock is a major species In the eastern Bering Sea, accounting for 27% of catches in NMFS trawl surveys on the middle shelf and 26% of catches adjacent to the NANZ (Table 5.4). Within the NANZ, however, pollock were only moderately abundant in our samples (Table 5.6) and those of Isakson et al. (1986).

Table 5.24. Rock sole diets (see Appendix 5.3E for more details).

	Diet Composition (% wt.) by Fish Size, Date and Location										
	Small Fish	Medium Fish			Large Fish						
	May 1984	Jan 1985	May 1984	July 1985	Jan 1985	May 1984a	May 1984b	July 1985a	July 1985b	Sept 1984a	Sept 1984b
Copepod	48	3		2							
Amphipod	26	37	52	4	13	3	4	8	2	8	31
Polychaete	22	36	39	71	46	87	44	70	2	79	10
Mysid		8	11	5							
Euphausiid								10			
Echinoderm*		8			14	1	12	6		3	5
Crangonid				1	7	3					
Bivalve				15		1	4	3	10	3	16
Echiuroid worm					12						
Sipunculid worm					7	3					
Flatworm							29				
Fish									84	1	29
Crab										2	7
Other	4	7	5	2	1	2	7	3		4	2
Ave. contents (mg)	5	8	44	27	130	700	2048	650	857	446	447
Ave. fish size (mm)	29	75	88	74	187	209	253	236	177	246	221
Sample site	2B	A,C	2C	D	A,C	2C	6A,7C	A-Y	D,E	A	1C
No. stomachs	15	36	28	31	31	10	31	39	13	38	15

*Urchins, sand dollars, brittle stars.

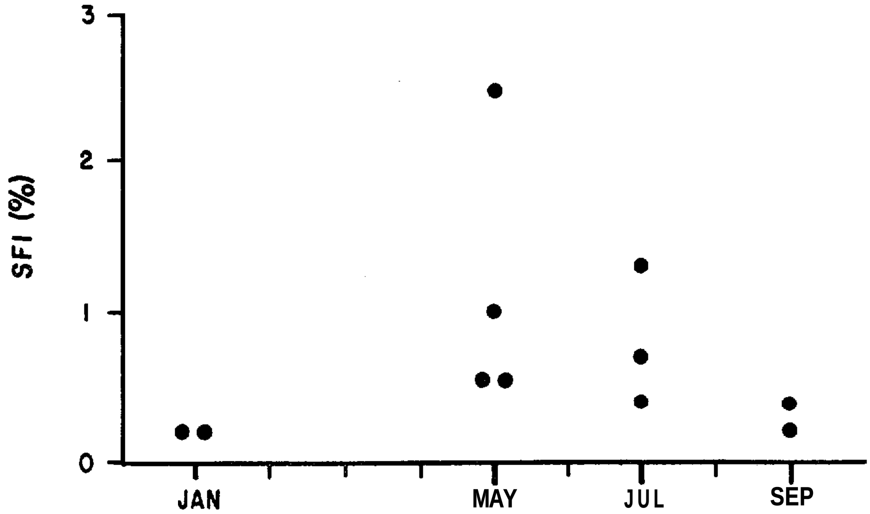


Figure 5.44. Seasonal stomach fullness index (SFI) of rock sole caught in the NANZ study area, Alaska. For each group of fish in Table 5.24, SFI = 100 x average weight of stomach contents divided by the average weight of fish in the group.

Table 5.25. Rock sole diets: comparisons between locations in the NANZ.

	Diet Composition (% wt.)			
	Dates Combined*		May 1984	
	Nearshore	Offshore	East	West
Polychaete	75	6	44	87
Fish	1	57		
Amphipod	8	17		3
Bivalve	3	13	4	1
Euphausiid	5			
Echinoderm	5	3	12	1
Crab	1	4		
Crangonid				3
Sipunculid worm				3
Flatworm			29	
Other	4	1	7	2
Ave. contents (mg)	652	548	2048	700
Ave. Fish size (mm)	199	241	253	209
Sample site	C-E	A-Y	6,7	2
No. stomachs	28	77	31	10

*September 1984, July 1985.

Pollock catches consisted primarily of young-of-year (25-100 mm) in the watercolumn, juveniles (81-180 mm) on the seabottom, and occasional adults (Fig. 5.45). Young-of-year or small juveniles were also caught by fyke net In Izembek Lagoon in July 1984 (Fig. 5.45).

The average catch of young-of-year in midwater trawls was only 1 mg/m^3 or 0.001 $fish/m^3$. Catches were highest in pollook biomass during summer months (Fig. 5.46) in offshore waters, as follows:

Transect Stations	Water Depth (m)	No. Stations Sampled	Young-of-Year Annual Mean (mg/m^3)
C	20	24	1
A	SO	2s	S
X,Y	70-90	10	17

Gear: M-4

Juvenile abundance was low during most sampling periods (Fig. 5.46), averaging 42 mg/m^2 or 0.003 $fish/m^2$.

This limited information agrees with Lynde's (1984) conceptual model of pollock distribution in the eastern Bering Sea (Fig. 5.47). Although some pollock of all sizes are present in the NANZ, we would expect to find primarily age 0 fish, especially when middle shelf waters intrude into the shallows of the study area.

The small pollook in the watercolumn were assumed to be age 0 fish. *Their* fork lengths (mm) were:

Month	Mean	Range	N
July 198s	46	25-80	248
September 1984	87	46-130	247
January 1985	103	77-130	25

Periods of high abundance of young-of-year pollock coincided with those of jellyfish in the NANZ (see Section 4.0, this report). While these

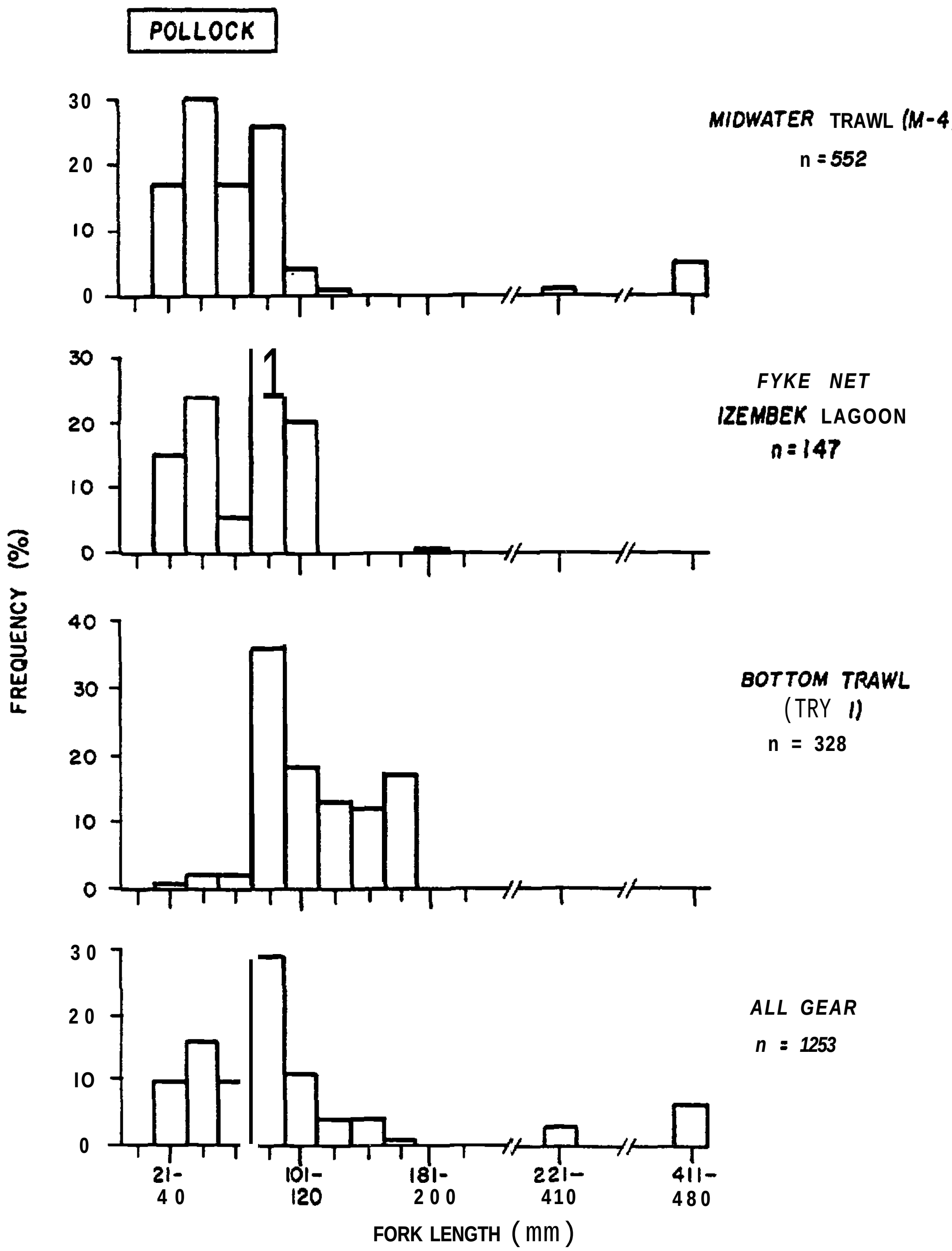


Figure 5.45. Length frequencies of pollock caught in the NANZ study area, Alaska. All dates and locations are combined. (Izembek Lagoon samples taken in July 1984 are excluded.)

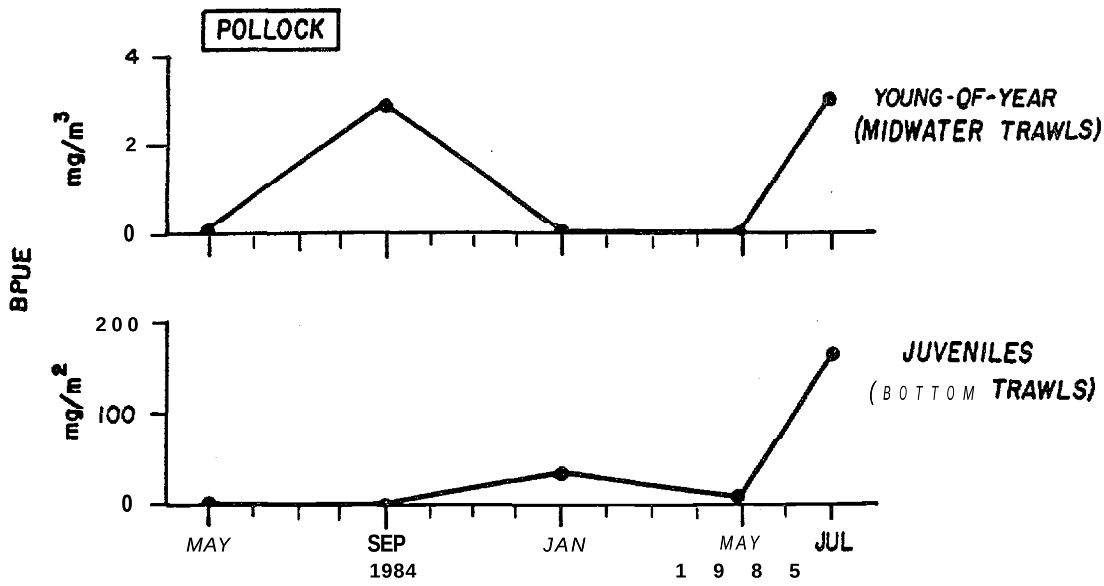


Figure 5.46. Seasonal, abundance of young-of-year pollock (25-100 mm) in the water column and juveniles (31-130 mm) in bottom trawls in the NANZ study area, Alaska.

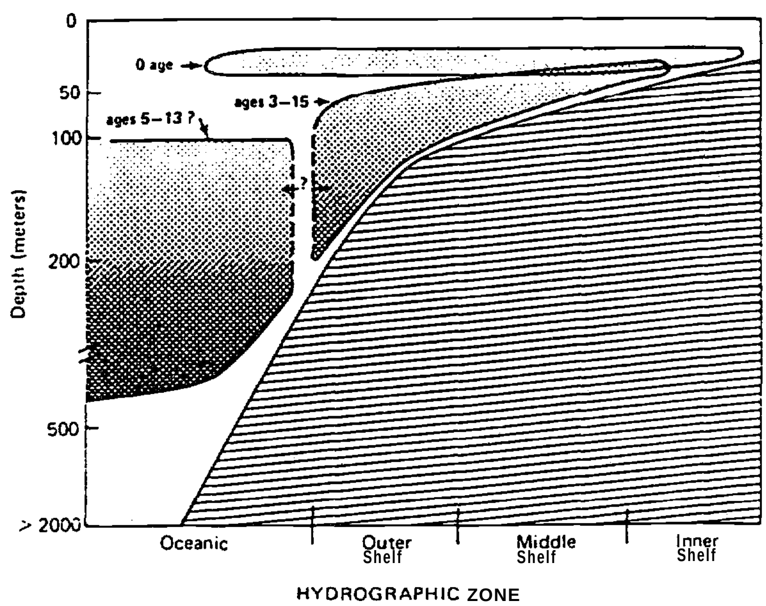


Figure 5.47. Conceptual model of the vertical distribution of juvenile and adult walleye pollock across the eastern Bering Sea shelf and slope, and Aleutian Basin areas. Age 1 and Age 2 pollock range throughout the water column over the outer, middle, and inner shelf domains. From Lynde (1984).

events may be unrelated, the juveniles of several cod species (including pollock and Pacific cod) are known to associate symbiotically with jellyfish medusae (Mansueti 1963, Van Hyning and Cooney 1974). By remaining near medusae, these juvenile fish presumably derive protection from other predators. A comparison was therefore made between catches of young-of-year pollock and medusae in mfdwater trawls, but no trend was detected; however, as previously noted, this negative result was not entirely unexpected because the midwater trawl used has a mesh size that is not 100% efficient at retaining very small fish.

Because of the economic and trophic importance of pollock in the Bering Sea, previous studies have closely examined the diets of larval fish (PROBES studies) and commercial-sized fish (NMFS surveys). Both size- and season-related trends in pollock food habits have been documented. Larval and young juveniles feed almost exclusively on copepods (Cooney et al. 1980); larger pollock eat copepods, euphausiids and fish in proportions that vary with the size of the pollock (Fig. 5.48). Dwyer (1984) notes that pollock feed primarily during the summer months.

Diets of pollook in very shallow water habitats and for the intermediate-size ranges of fish are not often reported in the literature. The NANZ data indicate that important foods of intermediate-sized pollock (40-150 mm) consist of amphipods, mysids and crustacean larvae, copepods, and euphausiids (Table 5.26). The diets of larger pollock were primarily euphausilds and fish, which is generally similar to that reported in the literature. And, as elsewhere, the amount of food in pollock stomachs tended to be greater in summer than winter (Fig. 5.49).

Pacific Cod (Gadus macrocephalus). Use of the study area by Pacific cod is similar to that described for pollock. Catches were moderately low, consisting primarily of young-of-year in the watercolumn, juveniles on the seabottom, and occasional adults (Pig. 5.50).

The average abundance of young-of-year caught in midwater trawls was only 02 mg/m^3 and 0.0001 $fish/m^3$; juveniles in bottom trawls averaged 28 mg/m^2 and 0.003 $fish/m^2$. Highest catches of biomass were in summer (July and September samples), averaging 0.1-0.8 mg/m^3 in midwater trawls and 62-73 mg/m^2 in bottom trawls.

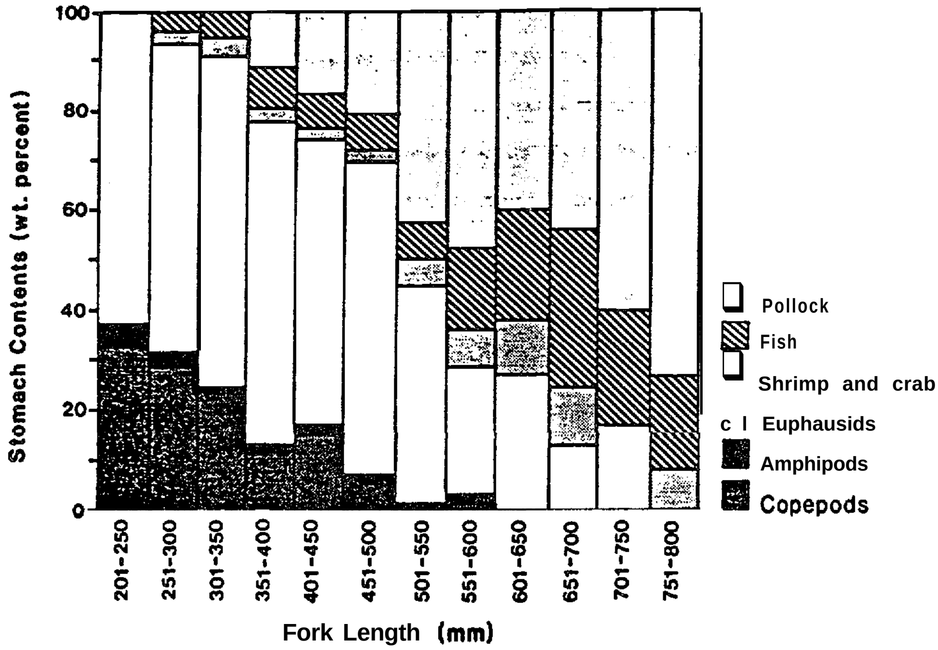


Figure 5.48. Changes in composition of pollock prey with size. From Takahashi and Yamaguchi (1972).

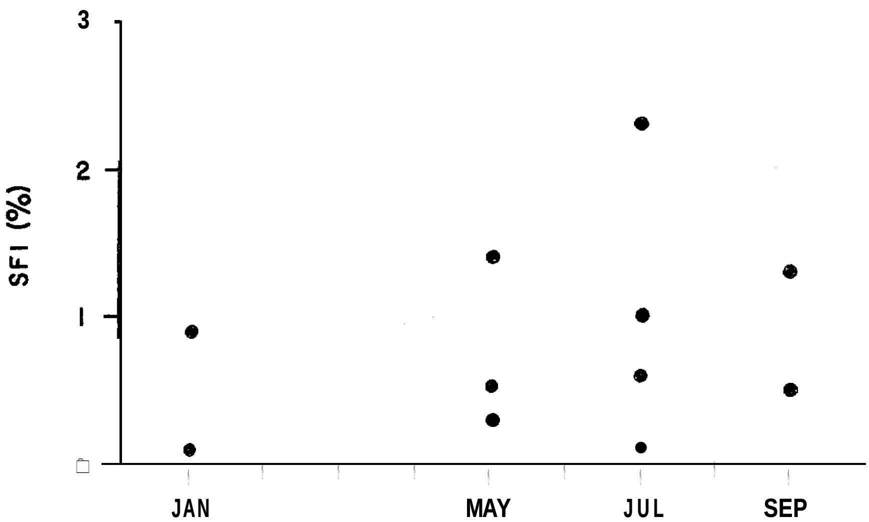


Figure 5.49. Seasonal stomach fullness index (SFI) of pollock caught in the NANZ study area, Alaska. For each group of fish listed in Table 5.26, SFI = 100 x average weight of stomach contents divided by average weight of fish in the group.

Table 5.26. Walleye pollock diets (see Appendix **5.3F** for more details).

	Diet Composition (% wt.) by Fish Size, Date and Location										
	Small Fish		Medium Fish					Larne Fish			
Food	July 1984	July 1985	Jan 1985	May 1984	July 1984	July 1985	Sept 1984	Jan 1985	May 1984	May 1985	Sept 1984
Deoapod larvae	1	15			7						
Crustacean larvae		75					3				1
Amphipod	59		16	2	28	5	18				
Copepod	22		1			2	56			4	
Mysid	6		5	70	15	69	2				
Crustacea misc.	9						11				4
Euphausiid			76	28				100	95	96	
Crangonid shrimp					4	14					14
Crab							3				
Fish					45	10			5		77
Other	3	10	2		1		7				4
Ave. contents (mg)	4	6	66	120	160	14	21	603	5100	1940	1383
Ave. fish size (mm)	45	43	101	106	99	148	86	479	515	457	246
Sample site	2F	A	A,C	misc	2F	D,E	A	X,Y	A	A	2A
No. fish examined	32	40	32	15	30	30	33	8	30	21	16

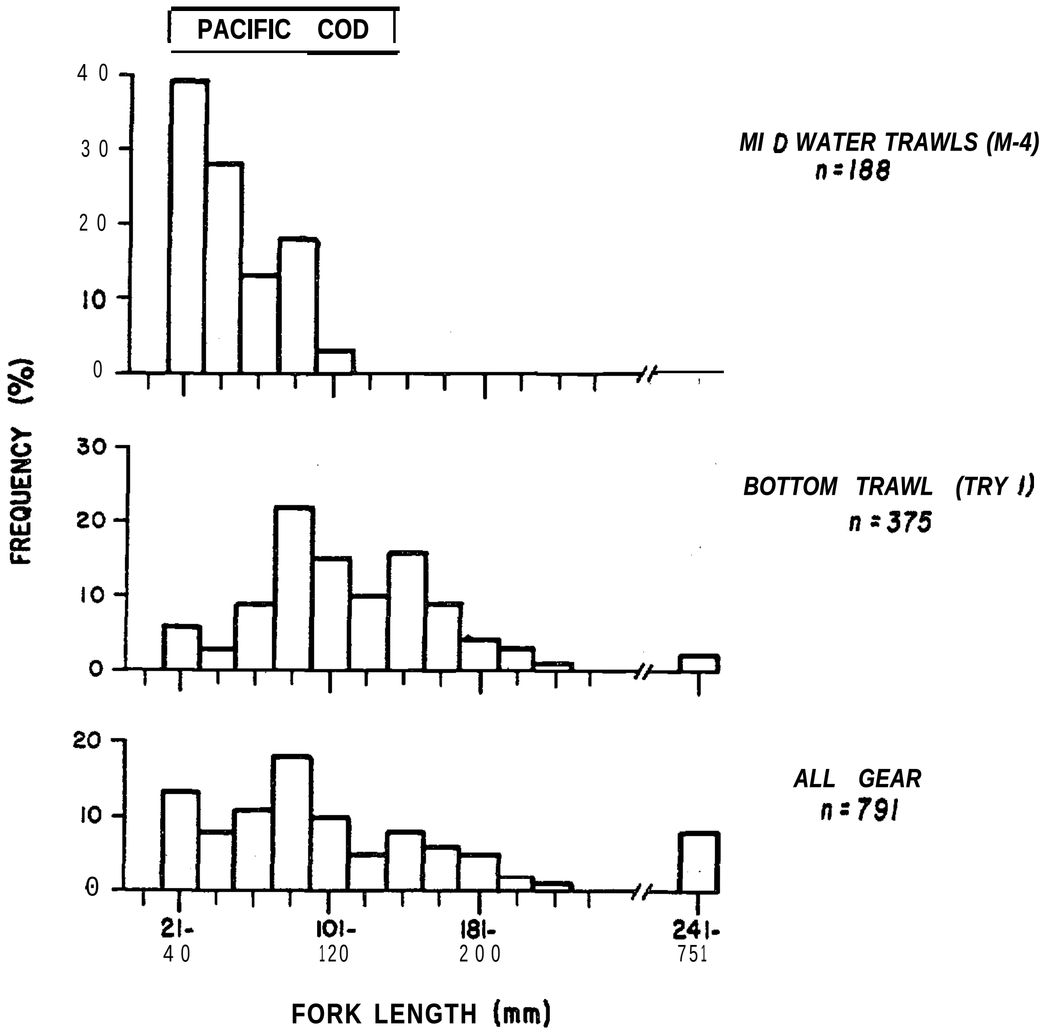


Figure 5.50. Length frequencies of Pacific cod caught in the NANZ study area, Alaska. Catches from all dates and locations are combined.

Information about the food habits of Pacific cod in the eastern Bering Sea is limited. Bakkala (1984) reports that their diets were geographically variable across the Bering Sea shelf and that the primary foods consumed were snow crab, euphausiids, fish, and other miscellaneous invertebrates.

In the NANZ, the foods eaten by Pacific cod were diverse (Table 5.27), but there was a definite change in prey types with change in fish size. Small Pacific cod (mean size 41 mm) ate copepods; medium-sized cod (mean sizes 88 and 191 mm) ate mostly small epibenthic invertebrates such as mysids, amphipods, and crangonid shrimps; large cod ate primarily fish and crabs.

Pacific Halibut (*Hippoglossus stenolepis*). Catches of halibut in small bottom trawls (TRY1) were low, averaging 4 mg/m^2 and 0.0001 $fish/m^2$ in 143 trawls. Highest catches were made in summer: 158 mg/m^2 (July) and 41 mg/m^2 (September).

Higher catches were made when a larger bottom trawl was used in deeper waters (maximum catch 897 mg/m^2, average catch 231 mg/m^2; gear = BT-1), but the sampling effort with this gear was low (n=4 trawls). A comparison of catches in large and small trawls at the same depth and time period (50 m, September 1984), though based on only three samples for each gear type, showed that the large trawl caught more halibut (TRY1: 0 halibut; BT-1: 0.001 $halibut/m^2$, 486 mg/m^2). The average size of these fish was 305 mm (range 184-527 mm, n=21).

Although most halibut caught by trawl (particularly the small trawl) measured less than 300 mm in length, larger fish were also present in the NANZ as indicated by samples collected by hook and line (Fig. 5.51).

The foods eaten by these fish demonstrate size-related changes in diet. Small halibut (mean size 66 mm) ate mysids, shrimp, and amphipods; medium-sized halibut (mean sizes 138 and 366 mm) ate fish, crabs, and crangonid shrimps; and large halibut (788 mm) ate fish, cephalopods, and crabs (Table 5.28).

Table 5.27 . Pacific cod diets (see Appendix 5.34; for more details.)

	Diet Composition (% wt.) by Fish Size, Date and Location					
	Small Fish	Medium Fish			Large Fish	
Food Item	July 1985	May 1984	July 1985	Sept 1984	May 1984	Sept 1984
Copepod	72			11		
Crustacea	11			19		8
larvae	13					
Amphipod		32	16	8		
Mysid		62	4	4		
Decapod						
Crangonid			60	26	1	8
Crab					28	13
Pagurid						23
Larvae, eggs	3			32		
Misc.			7			7
Fish			8		54	36
Other	1	6	5		17	6
Ave. contents (g)	0.02	0.16	1.01	0.06	20.9	4.1
Ave. fish size (mm)	41	99	191	88	526	394
Sample site	A,C	E,C	D,E	misc	A,C	B,C
No. fish examined	30	5	31	30	13	24

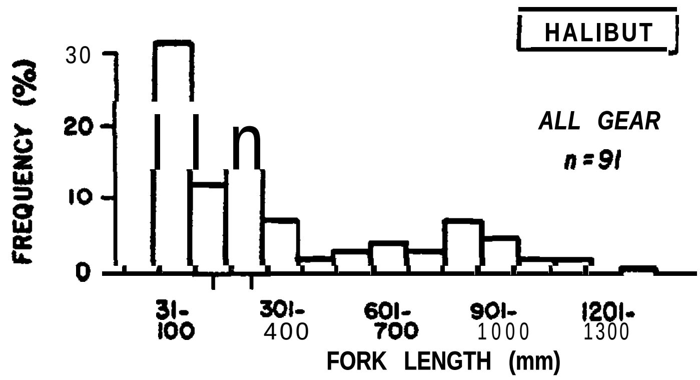


Figure 5.51. Length frequencies of halibut caught in the NANZ study area, Alaska. Catches from all gears, dates and sites are combined.

Table 5.28. Halibut diets (see Appendix 5.3H for more details).

	Diet Composition (%.wt.) by Fish Size and Location			
	Small Fish	Medium Fish		Large Fish
	Jan. 1985	July 1985	Sept 1984	July 1985
Mysid	51	6		
Amphipod	11			
Crustacea	9			
Shrimp (misc.)	28			
Crangonid shrimp		12	17	
Crabs		16	44	7
Fish		60	32	71
Cephalopods				19
Other	1	6	7	3
Ave. wt. contents (g)	0.15	0.64	5.3	28.4
Ave. fish size (mm)	66	138	366	788
Sample site	2C,4C	D	3,4	misc
No. fish	17	17	21	11

5.6.5.4 Nearshore and Other Fishes

Figure 5.52 presents length frequencies for Pacific sandfish, Pacific staghorn sculpin, Alaska plaice, flathead sole, and starry flounder. Of these, only the sandfish were moderately abundant in catches.

The 1610 sandfish caught in the NANZ measured 68-264 mm in length. They were occasionally caught in both midwater and bottom trawls, averaging 3 mg/m^3 and 16 mg/m^2, respectively. More were caught in winter and spring (21-40 mg/m^2) than in summer or fall (3 mg/m^2). Most were taken in shallow water, ranging about 3-25 m deep (i.e., Station C for midwater trawls and Station D for bottom trawls).

The 227 staghorn sculpin caught measured 42-375 mm (Fig. 5.52). This shallow-water species was taken in waters 20 m or less by bottom trawl, gill net, and beach seine.

Alaska plaice were caught in small numbers (n=269) throughout the study area, primarily by bottom trawl but also by beach seine and nearshore gill nets.

Flathead sole (n=151) were caught in bottom trawls in the western portion of the study area (Transects 1-4) in waters ranging from 10-90 m deep. These fish measured 48-341 mm.

Starry flounder (n=112) were usually caught by bottom trawl in waters 20 m or less, but occasionally out to 50 m. They were also taken by beach seine and nearshore gill net. These fish measured 48-550 mm.

5.7 RECOMMENDED FURTHER RESEARCH

1. Forage fishes such as sand lance, herring, and capelin are the most likely fishes to be impacted by an oilspill because they use intertidal or shallow coastal waters for spawning, feeding and migrating, and as a nursery area for their young. Sand lance also will avoid burrowing into oil-contaminated substrates (Pearson et al. 1984). Therefore, it would be useful to gain a better understanding of their seasonal abundance, spawning areas, the distribution of their juveniles, and their pre- and post-spawning migrations in the NANZ. For example, we do

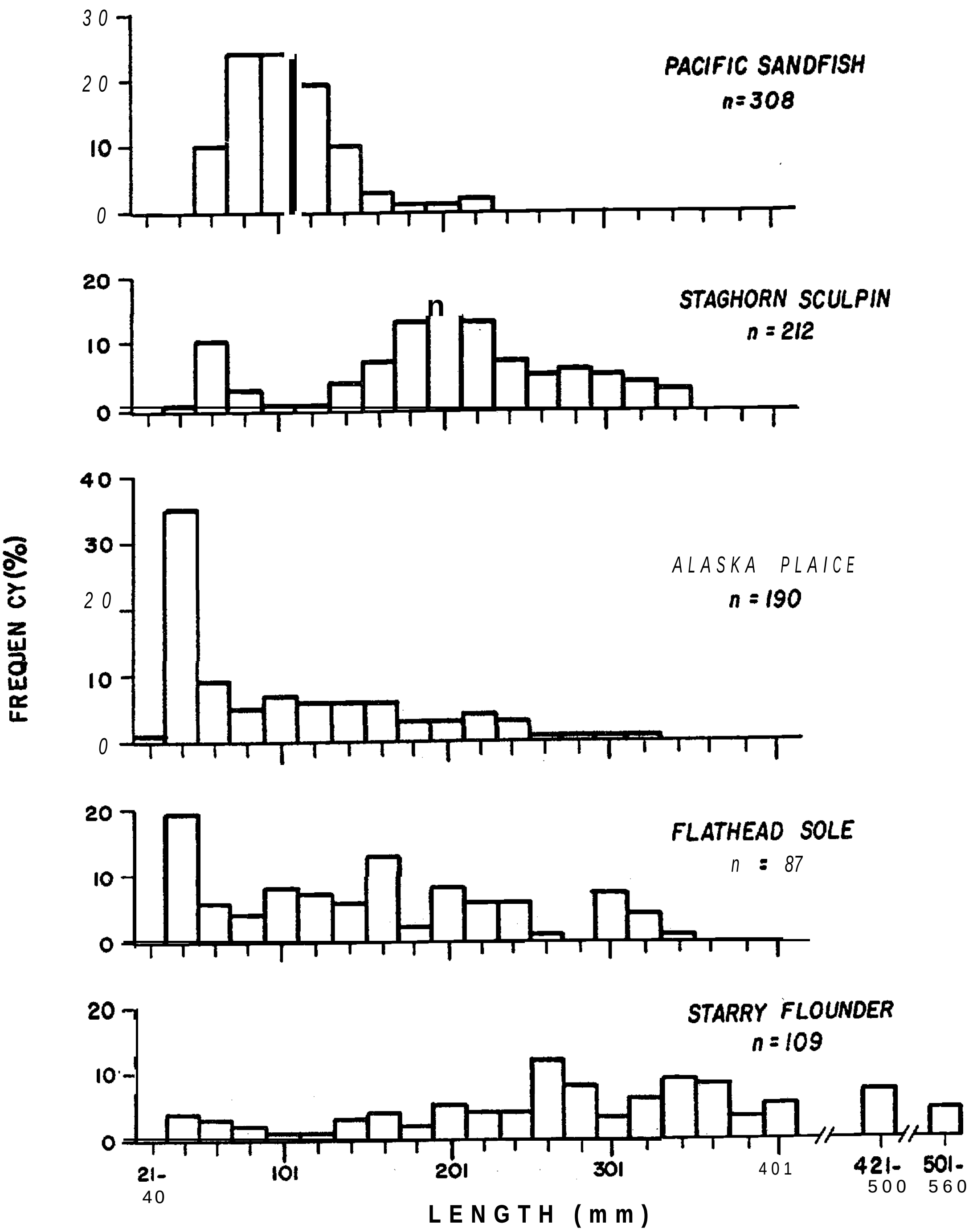


Figure 5.52. Length frequencies of five species caught in the NANZ study area, Alaska. Catches by all gear types and dates are combined.

not know where or when sand lance spawn in the eastern Bering Sea, or where they go in winter, which is the period when most of their feeding occurs. For herring and capelin, we know little about the distribution of larvae and juveniles, or the migration pathways of either the Port Moller spawners or the Togiak spawners, which migrate to the Unimak area to feed in summer.

2. Special habitats. Selected nearshore habitats such as Port Moller and Herendeen bays and Izembek Lagoon support both resident fish populations and important seasonal migrants such as juvenile salmon, herring, young-of-year pollock, sand lance and smelt. Fish use these areas for feeding and, at least for herring in Port Moller, as spawning and nursery areas as well. A better understanding of the role of these nearshore habitats to important fish species is needed.

3. Winter conditions. Most data describing NANZ fishes have been gathered during the 6-month summer period from April to September. Our January (1985) cruise in the study area represents one of the few attempts to address the need for an assessment of winter conditions. The data gathered indicate that there is an abundance of fish (particularly juvenile yellowfln and rock sole) that winter in the NANZ. The fisheries significance of nearshore habitats in winter needs further examination.

4. Fish-jellyfish relationships. In summer, two of the most abundant pelagic organisms in the NANZ (and eastern Bering Sea) are young-of-year pollock and jellyfish. The relationship between these two may be much more than an academic curiosity -- the ecological significance of jellyfish (and other gelatinous zooplankton) is receiving growing attention in the scientific literature. Due to

their often overwhelming abundance, jellyfish may affect fishes negatively or positively in several ways:

A. Predation. Jellyfish may seriously reduce numbers of larval fish. For example, Moller (1984) found that a larval herring population was less affected by the number of herring spawners than it was by the abundance of jellyfish.

B. Competition. As shown in the present study, jellyfish consumed about 50% of all available zooplankton in the water, thereby significantly reducing the amount of food available to fish (and seabirds).

C. Symbiosis. The juveniles of several cod species, including pollock and Pacific cod, are known to associate symbiotically with jellyfish (Mansueti 1963, Hyning and Cooney 1974). By remaining near medusae, the cod juveniles are presumably protected from other predators.

In all three of the above relationships, young-of-year pollock may be significantly influenced by jellyfish. This interaction merits investigation. Is it a mere coincidence that a major pollock spawning area lies adjacent to a site officially designated on maps as “Slime Bank” due to its well-known abundance of jellyfish?

5.8 ACKNOWLEDGEMENTS

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5.10 APPENDIXES

Appendix 5.1. Total fish catches, CPUE AND BPUE for individual gear types (all dates and sampling efforts combined).

Key to Tables

1. Gear Codes (see text Table 5.3).
2. Fish Species Codes (see text Table 5.5).
3. Total Biomass = grams.
4. Units:

Gear	CPUE	BPUE
Bottom trawls (TRY1=small, BT-1=large)	no. fish/m^2	mg/m^2
Mid-water trawls (M-3=period 1, M-4= periods 3-6)	no. fish/m^3	mg/m^3
Gill nets (GN-S, GN-B, GNXS, GNXB)	no. fish/hour	mg/hour
Beach series (BS-1 and BS-3, combined)	no. fish/haul	mg/haul
Fyke net (FYKE)	--experimental--	

Gear == TRY!

Location	Species	Total Samples	# Total Number	CPUE	Total Biomass	BPUE
ALL		143	0			
ALL	AHSC	143	1	.0000029	2.20	.0064
ALL	AKPL	143	255	.0007369	9927.30	28.6897
ALL	ALAL	143	17	.0000491	162.70	.4702
ALL	ARRO	143	6	.0000173	889.10	2.5695
ALL	BERF	143	4	.0000116	184.00	.5318
ALL	BPOA	143	151	.0004364	1136.60	3.2848
ALL	BUTS	143	6	.0000173	382.20	1.1045
ALL	CAPE	143	5	.0000144	55.20	.1595
ALL	CRES	143	1	.0000029	79.00	.2283
ALL	CRGU	143	11	.0000318	73.70	.2130
ALL	EULA	143	1	.0000029	97.00	.2803
ALL	F-l	143	2	.0000058	.20	, 0006
ALL	FLAT	143	128	.0003699	7430.10	21.4728
ALL	GRSC	143	6	, 0000173	3639.20	10.5172
ALL	GRTU	143	1	.0000029	82.30	.2378
ALL	HALI	143	47	.0001358	1312.80	3.7940
ALL	JAOK	143	7	.0000202	7076.00	20.4495
ALL	KGRE	143	7	. 0000202	72.50	.2095
ALL	L-l	143	2	. 0000058	1.10	.0032
ALL	LDAB	143	4	.0000116	178.80	.5167
ALL	LSPB	143	3	.0000087	131.10	.3789
ALL	MASK	143	3	. 0000087	46.40	.1341
ALL	P-l	143	5	.0000144	56.10	.1621
ALL	PCOD	143	941	.0027195	15390.90	44.4794
ALL	POLK	143	1175	.0033957	14524.80	41.9764
ALL	PRIC	143	5	.0000144	194.70	.5627
ALL	RBSM	143	854	.0024680	11169.60	32,2799
ALL	REDL	143	1	.0000029	585.50	1.6921
ALL	RIBS	143	2	.0000058	6.70	,0194
ALL	ROKS	143	2377	.0068695	87457.10	252.7491
ALL	SSDL	143	1	.0000029	434.00	1.2543
ALL	SAHL	143	976	.0028206	3871.50	11.1886
ALL	SCUL	143	9	.0000260	6.80	.0197
ALL	SILV	143	1	.0000029	8.90	.0257
ALL	SLIM	143	1	.0000029	4.60	.0133
ALL	SNAK	143	26	.0000751	488.80	1.4126
ALL	SNAL	143	53	.0001532	1167.60	3.3743
ALL	SSPO	143	1	.0000029	1.20	.0035
ALL	STAG	143	25	.0000722	6653.80	19.2293
ALL	STAR	143	49	.0001416	27625.20	79.8302
ALL	STUR	143	23	.0000665	323.30	.9343
ALL	TRIC	143	276	.0007976	5559.90	16.0969
ALL	TUBE	143	194	.0005607	310.70	. e979
ALL	WASC	143	3	. 0000087	3588.30	10.3701
ALL	WGRE	143	16	.0000462	345.40	I9982
ALL	YEIL	143	31	.0000896	17645.30	50.9945
ALL	YELS	143	4342	.0125483	445230.00	1286.7050
ALL	?F9	143	1	.0000029	42.10	.1217
			12056	.0348416	675662.30	1952.6500

Gear == BT-1

Location	Species	Total # Samples	Total Number	CPUE	Total Biomass	BPUE
ALL	AKPL	4	1	.0000303	1208.00	30.5353
ALL	ARRO	4	45	.0013629	8624.20	261.1890
ALL	BUTS	4	28	.0008480	6672.90	202.0927
ALL	FLAT	4	21	.0006360	9441.20	285.9323
ALL	GRSC	4	6	.0001817	5701.20	172.6642
ALL	HAL1	4	21	.0006360	7543.30	231.4819
ALL	HERR	4	8	.0002423	2251.90	68.2001
ALL	PCOD	4	142	.0043006	56781.80	1719.6700
ALL	POLK	4	6	.0001817	3320.90	100.5754
ALL	RBSM	4	1	.0000303	98.90	2.9952
ALL	ROKS	4	874	.0264696	165539.20	5013.4530
ALL	SABL	4	6	.0001817	2536.10	798359[illegible]
ALL	STAR	4	2	.0000606	1331.70	40.3313
ALL	YEIL	4	21	.0006360	8172.00	247.4938
ALL	YELS	4	174	.0052697	70715.60	2141.6640
			1356	.0410673	353138.90	10604.1600

Gear == M-3

Location	Species	Total # Samples	Total Number	CPUE	Total Biomass	BPUE
ALL		12	0			
ALL	POLK	12	7	.0000710	791.90	8.0310
ALL	ROKS	12	33	.0003347	1016.00	10.3036
ALL	SANL	12	53	.0005375	3808.90	38.5275
ALL	YELS	12	16	.0001623	1959.00	19.8669
			109	.0011054	7575.80	76.8290

Sear == M-4

Location	Species	Total # Samples	Total Number	CPUE	Total Biomass	BPUE
ALL		73	0			
ALL	CRES	75	1	.0000001	407.00	.0537
ALL	F-I	73	1	. [illegible]	1.20	.0002
ALL	FLAT	73	1	.0000001	6.70	.0009
ALL	HERR	73	678	.0000895	152464.60	20.1233
ALL	KAMC	73	1	.0000001	24.70	.0033
ALL	L-I	73	19	.0000025	3.10	.0004
ALL	L-2	73	10	.0000013	4.50	.0006
ALL	PCOB	73	744	.0000982	1610.40	.2126
ALL	POLK	73	11023	.0014549	39415.60	5.2023
ALL	PRIC	73	2	.0000003	32.20	.0042
ALL	RBSM	73	476	0000628	7632.80	1.0074
ALL	ROKS	73	4	. 0000005	680.60	.0898
ALL	SANL	73	60436	.0079767	272190.70	35.9255
ALL	SLUM	73	1	.0000001	0.00	0.0000
ALL	SMLP	73	1	.0000001	717.60	.0947
ALL	SNAL	73	b4	.0000084	1345.00	.1777
ALL	STAG	73	1	.0000001	509.00	.0672
ALL	STAR	73	1	.0000001	480.50	.0634
ALL	TRIC	73	983	.0001297	19161.30	2.5290
ALL	u-i	73	2	.0000003	102.80	.0136
ALL	YELS	73	12	.0000016	2102.00	.2774
			74461	.0098279	498893.40	65.8473

Appendix 5.1 (cont'd)

Gear == GNXS

Location	Species	Total Samples	# Total Number	CPUE	Total Biomass	BPUE
ALL		31	0			
ALL	AKPL	31	2	.0065270	101.00	329.6129
ALL	BPOA	31	1	.0032635	9.50	31.0032
ALL	CHUM	31	4	.0130540	12039.60	39291.1600
ALL	DOLL	31	3	.0097905	3663.00	11954.1800
ALL	GRSC	31	2	.0065270	745.50	2432.9340
ALL	MASK	31	3	.0097905	397.00	1295.6070
ALL	RBSM	31	22	IO717969	622.00	2029.8940
ALL	RGRE	31	2	.0065270	795.70	2600.0260
ALL	ROKS	31	4	.0130540	185.20	604.3991
ALL	SALM	31	1	.0032635	12.20	39.6146
ALL	SOCK	31	3	.0097905	3595.80	11734.8700
ALL	STAG	31	39	.1272763	8600.20	28066.7000
ALL	STAR	31	4	.0130540	622.00	2029.8939
ALL	STUR	31	1	.0032635	52.40	171.0071
ALL	TRIC	31	2	.0065270	247.40	807.3884
ALL	YELS	31	3	,0097905	279.10	910.8413
			96	.3132954	31968.60	104329.3000

Gear == GNXB

Location	Species	Total Samples	# Total Number	CPUE	Total Biomass	BPUE
ALL		16	0			
ALL	BPOR	16	11	.0727754	198.50	1313.2650
ALL	DOLL	16	8	.0529276	7410.00	49024.1500
ALL	GRSC	lb	1	.0066159	736.10	5200.7940
ALL	HALI	16	1	.0066159	3750.00	24809.7900
ALL	HERR	lb	3	.0198478	572.20	3705.6430
ALL	LSPB	16	I	.0066159	30.30	200.4631
ALL	MASK	16	15	.0992392	1137.40	7524.9763
ALL	PADS	lb	1	.0066159	30.40	201.1247
ALL	PCOD	16	57	.3771088	3662.50	24363.2200
ALL	POLK	lb	3	.0198478	27.10	179.2921
ALL	PRIC	lb	1	.0066159	31.70	209.7254
ALL	RBSM	lb	53	.3506451	2985.80	19753.8900
ALL	RGRE	lb	2	.0132319	1137.30	7524.3140
ALL	SOCK	lb	2	.0132319	377s. so	24978.5003
ALL	STAG	lb	28	.1852465	6364,80	42109.1605
ALL	STAR	16	11	.0727754	14078.60	93143.2490
ALL	STUR	lb	2	.0132319	119.30	739.2822
ALL	TOMC	16	1	.0066159	55.60	367.8465
ALL	TRIC	lb	40	.2646378	1491.90	9869.6670
ALL	WGRE	16	14	.0926232	1016.90	6727.7540
ALL	YELS	16	6	,0396957	796.20	52b7.5150
			261	1.7267620	49478.00	327343.7[illegible]

Appendix 5.1 (cont'd)

Gear == GN-S

Location	Species	Total # Samples	Total Number	CPUE	Total Biomass	BPUE
ALL		7	0			
ALL	TRIC	7	1	.0208333	27.00	562.5000
			1	.0208333	27.00	562.5000

Gear == GN-5

Location	Species	Total # Samples	Total Number	CPUE	Total Bioaass	BPUE
ALL		7	0			
ALL	FLAT	7	1	.0223464	363.00	3111.7310
ALL	HERR	7	2	.0446927	630.00	14078.2100
ALL	JADK	7	1	.0223464	852.00	19039.1100
ALL	PCOD	7	23	.5139665	37748.00	843530.7000
ALL	POLK	7	84	1.3770950	64459.00	1440424.0000
ALL	ROKS	7	26	.5810056	6867.00	153452.5000
ALL	SNAL	7	1	.0223464	0.00	0.0000
ALL	STUR	7	1	.0223464	118.00	2536.8710
ALL	YELS	7	40	.8938548	8019.00	179195.5000
			179	4.0000000	119056.00	2660469.0000

Appendix 5.1 **(cont 'd)**

Gear == BS

Location	Species	Total # Samples	Total Number	CPUE	Total Biomass	BPUE
ALL		63	0			
ALL	AKPL	63	8	.1269841	225.90	3600.0000
ALL	BFOA	63	14	.2222222	216.30	3433.3330
ALL	CHUM	63	247	3.9206350	2730.10	43334.9200
ALL	DOLL	63	5	.0793651	1390.10	30144.4400
ALL	F-1	63	5	.0793651	0.00	0.0000
ALL	GRSC	63	1	.0158730	3.10	49.2063
ALL	MASK	63	6	.0952381	83.30	1322.2220
ALL	PCOD	63	98	1.5555560	422.40	6704.7620
ALL	PINK	63	9	.1428571	25.10	398.4127
ALL	RBSM	63	183	2.9047620	1505.50	23896.8200
ALL	ROKS	63	9	.1428571	139.70	2217.4600
ALL	SALM	63	10	.1587302	49.70	788.8890
ALL	SANL	63	82	1.3915870	637.10	10112.7000
ALL	SCUL	63	1	.0158730	15.20	241.2698
ALL	SOCK	63	1	.0158730	14.20	225.3968
ALL	STAG	63	119	1.8888890	10547.80	167425.4000
ALL	STAR	63	41	.6507937	8861.90	140665.1000
ALL	STUR	63	4	.0634921	256.20	4225.3970
ALL	SURF	63	11	.1746032	477.10	7573.0160
ALL	TUBE	63	25	.3968254	33.63	533.3333
ALL	WGRE	63	3	.0476190	32.20	511.1111
ALL	YELS	63	7	.1111111	271.20	4304.7620
ALL	3ST	63	31	.4920635	125.70	1995.2380
			920	14.6031700	28583.30	453703.1000

Appendix 5.1 (cont 'd)

Izembek Lagoon:

e-e---------
Gear == FYKE

Location	Species	Total # Samples	Total Number	CPUE	Total Biomass	BPUE
ALL	AKPL	7	3		87.50	
ALL	BPOA	7	9		169.60	
ALL	CM!	7	4		17.20	
ALL	GREE	7	73		101.90	
ALL	GRSC	7	6		645.20	
ALL	L-!	7	2		0.00	
ALL	MASK	7	18		1516.40	
ALL	P-2	7	2		7.60	
ALL	PCOD	7	9		101.00	
ALL	PINK	7	I		4.10	
ALL	POLK	7	147		669.00	
ALL	RBSM	7	3		181.90	
ALL	SANL	7	3		21.00	
ALL	SILV	7	19		53.50	
ALL	SNAL	7	1		8.00	
ALL	SOCK	7	6		0.00	
ALL	STAG	7	12		2186.30	
ALL	STAR	7	1		727.00	
ALL	SURF	7	3		18.90	
ALL	TRIC	7	2		12.00	
ALL	TUBE	7	131		444.90	
ALL	WGRE	7	15		1662.20	
			476		8690.20	

Appendix 5.2. Seasonal CPUE and BPUE, fish species combined; gear oodeo are listed la Table 5.3.

A. Fish **CPUE (sampling effort In parentheses)**

Gear CodeO	May 1984	July 1984	Sept. 1984	Jan. 1965	May 1985	July 1985	Mean
Gill Nets (no./h)							
GN-S	0.20(7)						
GN-B	4.00(7)						
GNXS	0.00(6)	0.53(5)	0.34(6)		0.05(5)	0.30(9)	0.31(31)
GNXB			1.29(6)		0.00(3)	1.97(7)	1.73(16)
Beach Seine (no./haul)							
BS-1	34.00(9)					9.5(23)	16.40(32)
BS-3		28.5(6)	11.7(19)		0.00(5)		13.10(30)
Bottom Trawl (no./m^2)							
TRY1	0.02(36)		0.04(38)	0.04(26)	0.05(15)	0.05(28)	0.04(143)
ET-1			0.05(3)			0.03(1)	0.04(4)
Hid-Water Tr. (no./m^3)							
M-3	0.001(12)						
n-4			0.02(22)	0.001(16)	0.001(13)	0.02(22)	0.01(73)

B. Fish **BPUE (sampling efforts as** above)

Gear Codes	May 1904	July 1984	Sept. 1985	Jan. 1985	May 1985	July 1985	Mean
Gill Nets (g/h)							
GN-S	0.60						
GN-B	2660.00						
GNXS	0.00	262.00	11.00		31.00	74.00	104.00
GNXB			323.00		0 .00	361.00	327.00
Beach Seine(g/haul)							
BS-1	643.00					673.00	664.00
BS-3		462.00	239.00		0.00		244.00
Bottom Trawl (g/m^2)							
TRY1	1.30		2.00	1.00	4.50	3.20	2.00
BT-1			8.50			15.00	10.60
Mid-Water Tr. (g/m^3)							
M-3	0.77						
M-4			0.05	0.004	0.02	0.20	0.07

Appendix 5.3. Detailed listings of fish diets.

A. Sand Lance Diets

Food Item	Jan 1985	May 1984		May 1985	July 1985[1]		Sept 1988[1]		
	Diet Composition (% wt.) by Date, Station and Fish Site								
Copepod	*	*	21	58	93	79	96	88	96
Euphausiid (Total)	(100)	(55)	(66)			(1)	(*)		
Thysanoessa inermis	30	16	38						
T. raschii	19		6						
Misc. and unident.	51	39	22						
Amphipod (Total)		(20)	(20)			(1)		(8)	(1)
Gammarid		5							
Corophiid		5				*			*
Hyperiid		*	2			1		8	1
other		10	*						
Mysid (Total)	*	(13)	(9)						*
Ancanthomysis			9						
Neomysis		6							
Misc. and unident.		7							
Misc. Crustacea (Total)		(2)	*	(30)		(5)	(1)	*	(1)
Larvae, nauplii						5	1		1
Decapod larvae, zoea		*		12	1	6			
Polychaete		6	*			1	1		
Chaetognath			2			1		3	
Fish eggs, larvae	*	1	1			1			
Bivalvia					5		1		*
Barnacle larvae					1	2		*	1
Plant		1					1		
Misc.			*			*		*	*
Average contents (mg)	120	80	270	10	10	60	10	40	50
Fish size (mm)									
mean	101	146	129	109	93	126	83	114	105
range	65-185	113-169	82-191	78-128	85-100	101-159	70-99	100-135	73-157
Sample location[2]	misc.	E	C	misc.	C	C	C	C	A,B
no. fish examined	9	46	40	24	33	30	45	29	32

* < 0.5%.

[1] Note differences in fish size at bottom of table.

[2] Station codes: E (lagoon), C (20m), AB (30-50m), x (combined).

Appendix 5.3 **(cont'd).**

B. Rainbow Smelt Diets

Food Item	Medium Fish May 1984	Medium Fish Sept 1984	Large Fish Sept 1984
	Diet Composition (% wt) by Fish Size, Date and Location		
Amphipod (Total)	(41)	(24)	(*)
Lysianassid	6	*	
Corophiid	2	*	
Gammarid	19	23	
Mysid (Total)	(39)	(68)	(29)
Neomysis zerniawski	38	'1	
N rayii		37	7
N. mirabilis		21	12
Anthomysis pseudomacropsis		6	•
Caridean Shrimp			11
Crangonid Shrimp (Total)			(35)
Crangon septemspirosa			17
Fish		6	24
Cyprid (barnacle) larvae	13		
Copepoda	1	1	*
Crustacean larvae	1		1
Cumacea	4	*	*
Polychaete	1	1	*
Misc.	1	•	
Average Contents **(mg)**	107	48	215
Fish Size **(mm)**			
mean	114	111	184
range	104-138	91-135	140-258
Sample Location	6E	6C,7D	D
No. Fish Examined	33	36	47

• < 0.5%

Appendix 5.3 **(cont'd)**.

C. Juvenile Salmon Diets

Food Item	Sockeye 1984	Chum July 1984	Chum July 1984	Chum Sept. 1984	Coho 1984	Pink July 1984
	Diet Composition (% wt) by Species, Date and Location					
Euphausiid (Total)	(42)				(1)	
Thysanoessa	19				*	
Misc.	23				*	
Fish (Total)	(36)		(13)	(95)	(93)	
Saud lance	24			67	88	
Misc.	12		13	28	5	
Mysid (Total)	(7)	(18)		(3)	(*)	
Acanthomysis	3					
Neomysis		13				
Misc.	4	5		3	*	
Barnacle Larvae	6				*	1
Insects (Total)	(5)		(31)	(1)	(1)	
Diptera	5		2	*	1	
Coleoptera			18			
Hymenoptera			g.			
Misc.			2	*		
Amphipod (Total)		(27)	(20)	(*)	(5)	(39)
Gammarid		10	1		1	8
Corophiid		4	7		1	18
Caprellid			1			4
Calliopiid		5	1 1	*		2
Misc.					3	7
Copepod	*	3	2	*	*	28
Decapod Larvae	1	45	4		1	24
Cuntacea	*	6	4		a	4
Crustacea	2					
Polychaete		1	1	*	*	4
Chaetognath	2					
Plant			25			
Average contents (mg)	429	116	29	864	1410	38
Fish size (mm)						
mean	107	82	75	134	129	75
range	90-132	64-108	70-80	114-152	90-111	63-86
Sample sites	misc.[1]	2F	2F	PH[1]	misc.[1]	2F
No. fish examined	30	30	30	20	26	7

* < .05%

[1] Samples from combined locations and dates (Izemgek Lagoon to Port Heiden, June-Sept, 1984) provided by J. Isakson (Dames and Moore).

Appendix 5.3 **(cont'd).**

D. Yellowfin Sole Diets

	Diet Composition (% wt.) by Fish Size, Date and Location										
	Small Fish			Large Fish							
Food Item	May 1984	July 19858	July 1985b	Jan. 1985	May 1984a	May 1984b	May 1985	July 1985a	July 1985b	July 1985c	Sept. 1984
Amphipod(Total)	(81)	(10)	(17)	(4)	(5)	(8)	(1)	(2)	(2)	(1)	(11)
Corophiid	66	3		•	2	6	*		*	*	4
Haustoriid			5				*		*		
Atylid		3	4		*		•	*	*		
Oedlcerotld	*		5.	*	*	•	*				*
Misc.	15	4	3	(35)	(*3	2		2	1	1	7
Polychaete **(Total)**	(3)	(17)	(5)	25		(46)	(41)	(47)	(7)	(35)	(*)
Errant	*		2			5	4	47			*
Sedentary			2	9		7	21	*	3	3:	•
Misc.	3	17	1	1	*		16		4	3	
Decapod **(Total)**	(1)	(8)	(1)	(27)	(6)	(18)	(13)	(9)	(33)	(8)	(51)
Crangonid			1	27	4			2	1		
Crangonus dalli						1	l	6	26	1	
C. septemspinosa									6	5	19
Pagurid		6				17		*			
Misc.	1	2			2	*		1		2	32
Fish (Total)			(73)	(3)		(7)	(2)	(28)			(3)
Sand lance						7					
Larvae			27								
Misc.			46	3			2	28			3
Euphausiid	*			2	9	•	•			4	
Mysid		1		•		1		•	*	*	*
Gastropod	*				*	*				11	
Bivalve (Total)	(8)			(6)	(76)	(1)	(18)	(15)	(17)	(22)	(26)
Macoma				6				2	16	1	
Mussel							8				
Misc	8				76	1	10	13	1	21	26
Echinoderm (Total'	(5)			(1)	(4)	(13)	(11)			(10)	
Echinoid	*				2		6			1	
Sand dollar	5				2	13	5				
Brittle **star**	*				•					9	
Misc.				1							
Copepod		60	2	•			*				
Cumacea	*		1	•	*	2	1		*	•	
Barnacle larvae		4	*								
Crustacea misc.	1			7	•		•				
Jellyfish								*			
Euchurian worm				15							
Isopod		*					a				•
Plant			•				2		39		5
Other	1				2	4.	3		2		4
Av. contents **(mg)**	224	11	67	209	2939	1795	695	413	312	576	260
Fish size **(mm)**											
mean	115	76	104	212	222	243	251	183	280	290	216
range	101-128	61-90	82-119	144-330	162-287	154-319	152-368	151-245	153-3%	207-363	134-330
Sample location	2B,C	D,E	D	A,C	2B,C	6A,C	Misc.	1D,E	6D	X,Y	6D
No. fish examined	18	32	30	25	17	46	33	24	38	28	23

* < .05%.

Appendix 5.3 (cont'd).

2. Rook Sole Diets

Food Item	Small Fish May 1984	Medium Fish Jan. 1985	Medium Fish May 1984	Medium Fish July 1985	Large Fish Jan. 1985	Large Fish May 1984a	Large Fish May 1984b	Large Fish July 1985a	Large Fish July 1985b	Large Fish Sept. 1984a	Large Fish Sept. 1984b
	Diet Composition (% wt) by Fish Size, Data, and Location										
Polychaete (Total)	(22)	(31)	(39)	(71)	(46)	(87)	(44)	(70)	(2)	(79)	(10)
Errant	11	6	4		20	9	31	20		51	4
Sedentary		8		71	24		5	17		20	6
Misc.	11	17	35		2	78	8	33	2	8	*
Amphipod [Total)	(26)	(37)	(52)	(4)	(13)	(3)	(4)	(8)	(2)	(8)	(31)
Corophiid		7	36	3	5	2	2	1		2	30
Oedicerotid		15		*	6			*		*	
Misc.		15	16	1	2	1	2	7	2	6	1
Mysid		6	2	5		*		*		*	
Euphausiid		8	2			*	*	10			
Decapod (Total)			(3)	(1)	(8)	(3)		(*)	(*)	(2)	(8)
<u>Crangon dalli</u>				1	7	3					
Crab								*	*	2	7
Misc.			3		1						1
Echinoderm (Total)		(8)	(*)		(14)	(1)	(12)	(6)		(3)	(5)
Sand dollar					6	1	8				
Urchin		8			8						
Echinoid uaident.								5		3	
Ophiuroid							3	1			
Holothuroid							1				2
Copepod	48	3		2	*						
Cumacea		7	1	1		*	*	1		2	*
Fish (Total)									(84)	(1)	(29)
Sand lance									71		
Misc.									13	1	29
Crustacea		*	1		1	1	1	1		*	
Nemertean							8				
Bivalve				15		1	4	3	10	3	16
Flatworm							29				
Sipunculid					7	3					
Echuria					12						
Other	4			1		1		1	2	2	1
Average contents (mg)	5	8	44'	27	130	700	2048	650	857	446	447
Fish Sire (mm)	29	75	88	74		209	253				
mean	21-	48-	53-	50-	187	140	145	236	177	246	221
					123-	-	-	128-	132-	149-	118-
range	41	123	106	100	308	273	326	379	323	340	277
Sample location	2B	A,C	2C	D	A,C		6A,7C	A,X,Y	D,E	A	1C
No. fish examined	15	36	28	31	31	2C 10	31	39	13	38	15

* < .05%

Appendix 5.3 (cont'd).

F. Walleye Pollook Diets,

	Diet Composition (% wt) by Fish Size, Date and Location										
	Small Fish		Medium Fish					Large Flab			
Food Item	July 1984	July 1905	May 1984	July 1904	Sept. 1984	Jan. 1985	July 1985	May 1984	Sept. 1984	Jan. 1905	May 1985
Amphipod (Total)	(59)		(2)	(28)	(18)	(16)	(5)	*	*	*	*
Hyperiid					6	4					
Gammarid	11			0	6	*	1				
Caprellid	7			1	*						
Atylld				1		1	3				
Pontogeneia				3							
Corophid	15		1	3	4	*					
Oedicerotid				*		3					
Misc.	26		1	12	2	0	1				
Decapod (Total)	(1)	(15)		(11)	(3)		(14)		(16)		(*)
Larvae	1	15		7			*				*
Crab				*	3						
Crangonid				4			14		14		
Misc.									2		
Mysid (Total)	(6)		(70)	(15)	(2)	(5)	(69)	*			*
Archeomysis grebnitzkii	3		2	2	2						
Acanthomysis psuedomacropsis			11				1	*			
Neomysis czerniawski			13								
mayii			11				24				
N. mirab lis				5			10				
Misc.	2		33	8			34				
Euphausiid (Total)			(28)	(*)		(76)		(95)		(100)	(96)
Thysanoessa inermis						16				9	26
T. raschii										7	1
Thysanoessa spp.								[illegible]		67	
Misc.						60				16	69
Crustacea	9				11	*			4		
Larvae		75		*	3		*		1		
Fish (Total)				(45)			(10)	(5)	(77)	(*)	(*)
larvae				13							
Misc.				32							
Cypsis Larvae				*	2			[illegible]	*		
Copepod	2:			*	56	1	2			*	4
Polyohaete				1			*		2		*
Pteropod					1						
Chaetognath					2	1					
Eggs		10									
Misc.	1				1		1				
Average Contents (mg)	4	6	120	160	21	66	14	5100	1383	603	1940
Flab Size (mm)											
mean	45	43	106	99	86	101	148	515	246	479	457
range	37-50	35-40	69-119	82-114	55-120	89-120	133-156	457-602	228-364	455-509	354-579
Sample location	2F	A	misc.	2F		AC	D,E	A	2A	X,Y	A
No. Flab examined	32	40	15	30	3:	32	30	30	16	0	21

* < 0.5%

Appendix 5.3. (cont'd) .

G. Pacific Cod Diets

Food Item	Small Fish July 1985	Medium Fish May 1984	Medium Fish July 1985	Medium Fish Sept 1984	Large Fish May 1984	Large Fish Sept 1984
	Diet Composition (% wt) by Fish Size, Date and Location					
Fish (Total)			(8)		(54)	(36)
Sand Lance					12	
SOPS					12	
Misc.			8		30	36
Decapod (Total)	(3)		(67)	(58)	(25)	(52)
Crangonid			60	26	1	8
Crab					28	13
Pagurid						23
Larvae, eggs	3			32		
Misc.			7	*		7
Amphipod (Total)		(32)	(16)	(8)	(*)	(*)
Lysianissid			5	1		
Atylid			7	2		
Gammarid			2	1		
Misc.		32	2	4		
Mysid (Total)		(62)	(4)	(4)	(*)	(*)
Acanthomysis		30		3		
Misc.		32	4	1		
Euphausiid		2			1	
Crustacea	11			19		7
Larvae	13					
Copepod	72	2		11		
Ostracod		1				
Anemone					7	
Polychaete			1		1	2
Gastropod eggs					7	
Isopod			3	*		*
Plant			1			1
Misc.		1			1	2
Average Contents (g)	0.02	0.16	1.01	0.06	20.9	4.1
Fish Size (mm)						
mean	41	99	191	88	526	394
range	32-54	89-109	143-236	70-115	330-683	324-336
Sample location	A,C	E,C	D,E	misc.	A,C	B,C
No. fish examined	30	5	31	30	13	24

* < .05%

Appendix 5.3 (cont'd).

H. **Halibut Diets**

Food Item	Diet Composition (% wt) by Fish Size, Date and Location			
	June 1985	July 1985 Small	July 1985 Large	Sept. 1985
Deoapod (Total)	(28)	(31)	(7)	(69)
Crab		16		
Canoer				40
Telmessus			2	
Oregonia	?		*	1
Hyas	3		1	
Crangonid		7		3
Crangon dalli				14
C. stylirostris		5		
Shrimp (misc.)	28			
Pagur id			it	3
Misc.		3	*	8
Crustaoea	9			*
Amphipoda (Total)	(11)	(*)		(*)
Corophiid	1	•		
Calliopiid	1			
Oedicerotid	9			*
Misc.		*		•
Mysid (Total)	(57)	(6)		
Aoanthocephala	30	6		
Misc.	21	*		
Fish (Total)		(60)	(71)	(32)
Sand lance			12	
Agonid			4	
Pholis laeta			3	
Halibut		4		
Flatf ish			13	
Misc.		56	39	32
Copepod	1			
Cephalopod			19	
Isopod			1	*
Plant		2	*	1
Average Contents (mg)	147	640	28390	5310
Fish Size				
mean	66	138	788	366
range	50-83	86-262	610-1100	210.900
Sample location	2C,4C	D	misc.	3,4
No. fish examined	17	17	11	21

* < .05%